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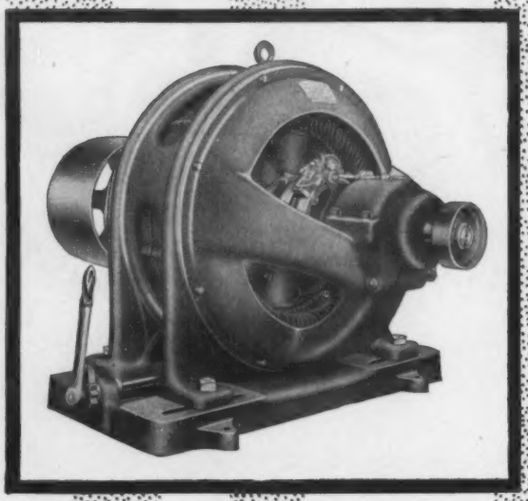

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ELECTRIC POWER IN THE CONSTRUCTION OF THE LOS ANGELES AQUEDUCT[1]

BY E. F. SCATTERGOOD.

Excavation in Los Angeles Aqueduct

The Los Angeles aqueduct extends from the intake in Owens valley, about 12 miles north of the town of Independence, to the storage reservoirs at the head of the San Fernando valley, about 24 miles distant from the city of Los Angeles, from which point the city water department will take care of the distribution of the water. The length of the aqueduct proper is, therefore, 240 miles.

From the southern end north to the north portal of the Elizabeth lake tunnel, a distance of 35 miles, the work is heavy, being to a considerable extent composed of tunnels, including the Elizabeth lake tunnel,

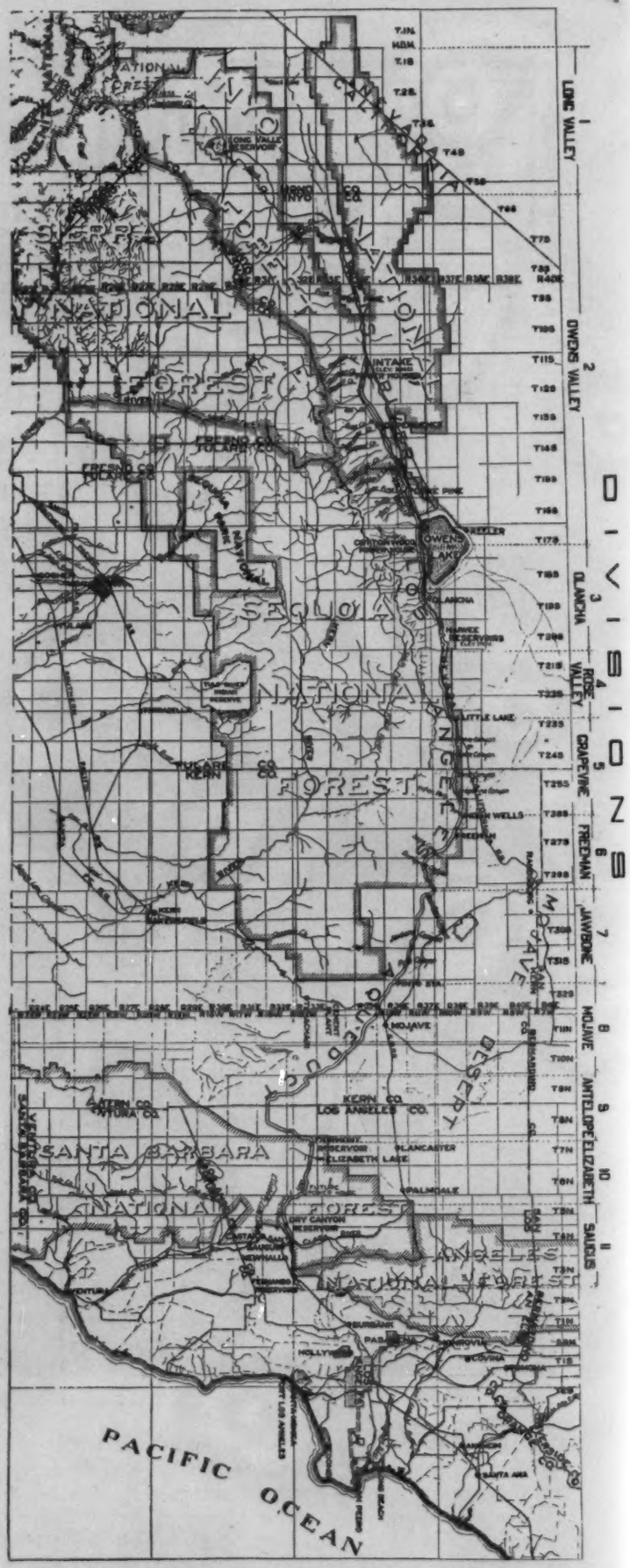
[1]Paper presented before the Los Angeles Section of the American Institute of Electrical Engineers, March 22, 1910.

some 27,000 ft. in length, through granite rock. Preliminary estimates showed that in such sections the considerable amount of power required could be furnished much more cheaply, from a central generating plant and distributed by high tension transmission, than by small power generating units, either by steam or distillate engines at various points as required. This section is supplied with power purchased from the Southern California Edison Company, and delivered at one of its sub-stations about four miles west of the aqueduct line and near the center of this section. From the Elizabeth lake tunnel to a point 55 miles further north, the aqueduct follows along the desert in the open, and estimates indicated that the conduit excavation, and concrete work of lining and cover, could be done more cheaply with the use of steam shovels and gas engines than by the erection of a temporary electrical generating and distributing system. From the Pinto hills north to the intake, a distance of 150 miles, there are alternate sections of the heavy tunnel work and of the lighter conduit work. In the Owens valley there are numerous creeks flowing down the eastern slope of the Sierra Nevada mountains offering excellent opportunities for power in sufficient quantities for construction work on the aqueduct; and estimates showed clearly that power could be developed at these creeks and transmitted along this 150 miles, and delivered to all points requiring power, in large or small amounts, at a very much lower cost than that for which it could be furnished in any other way.

It should be stated for the benefit of those who are not so familiar with the city's project, and who may read this paper, that the power referred to here is for construction purposes only, and should not be confused in any way with the large amount of electric power which may be developed along the line of the aqueduct when it is in operation, and which will total a peak load capacity of 120,000 h.p. delivered at step-down voltage in the city.

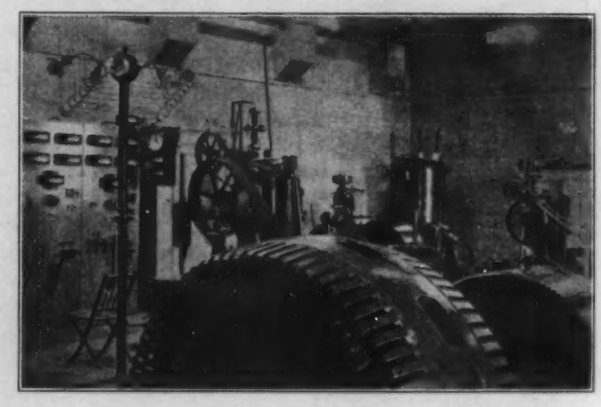
Power System.

For the purpose of supplying power along the section of the aqueduct from the intake to the Pinto hills, hydroelectric plants were installed on Division and Cottonwood Creeks. The Division Creek plant is about three miles south from the aqueduct intake, and has a rated capacity of 600 kw. The works at the point of diversion at the creek cost $1214. The penstock starting from this point, and extending down the slope 10,500 ft., consists of 6291 ft. of 18-in. riveted pipe and 4209 ft. of 15-in. lap-welded pipe, and cost, in place, $28,102. The effective head obtained is approximately 1200 ft. The power house equipment consists of one tangential wheel direct connected to a 2200-volt, three-phase, 600 r.p.m. generator and a bank of transformers, stepping the voltage up to 33,000, each of which has a continuous overload capacity of 25 per cent above the 600-kw. rating. The power house is built of concrete in a substantial manner. This is also true of the second one to be described, as these plants are intended to become a part of the permanent aqueduct power system. The cost of the power house and equipment, including three cottages, etc., is $21,100, making a total cost of approximately $84.50 per kw., or $63 per h. p. rated capacity at the switchboard.



Map of Los Angeles Aqueduct and Adjacent Territory.

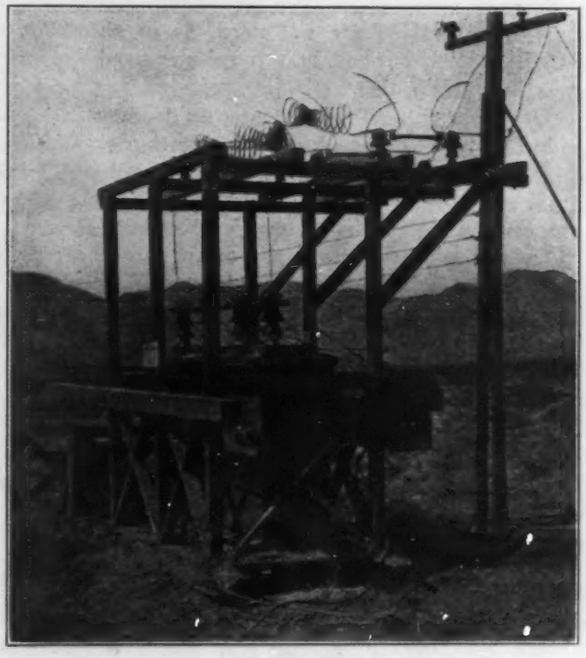
The Cottonwood power house is approximately 40 miles south from the Division Creek plant. Its equipment consists of two tangential wheels, operated under 1200 ft. effective head, each direct connected to a 750-kw. three-phase, 2200-volt, 600 r.p.m., generator, each of which in turn is connected to the 33,000-volt line through a separate bank of transformers. The works at the diversion point cost $3564. The canyon for a distance of 3750 ft. is so precipitous as to make a conduit or tunnel impracticable within reasonable cost, therefore, a 24-in., No. 12 gauge, riveted pipe was buried along the side of the canyon, at a cost of $9352. From this point to the forebay, a distance of 7042 ft., a covered concrete conduit, 30 in. by 20 in. inside section, was constructed on the mountain side at a cost of $11,228. The penstock, with 523 ft. of 24-in. pipe and 4009 ft. of 22-in. pipe, or a total of 4532 ft., cost $29,820. The power house and camp complete cost $49,638, making a total of $69.40 per kw., or $51.75 per h.p. of rated capacity at the switchboard, the plant having 25 per cent overload capacity.



Cottonwood Power House—two 750-kw. generators—Power all utilized for Construction Work.

The transmission line is 151 miles long, and is made up of three No. 4 bare copper wires; two-part seven-inch porcelain insulators with iron thimbles, pins and bases; one wire on a 15-in. crossarm at the top of a 30-ft. pole, and two on a 6-ft. crossarm below, and poles spaced 180 ft. apart. The average cost of this line is $862.50 per mile. About one-fifth of this line is through rough mountainous country, and the wagon haul for the entire line an average of 12 to 15 miles. This line has since been extended from its southern end to the aqueduct cement plant, a distance of 17 miles, with No. 2 copper, at a cost of $1050 per mile. The object of this extension is to deliver surplus power to the cement plant, with the advantage of supplementing the steam plant, thus saving fuel oil and making the entire system more flexible and reliable by running in parallel with two 750-kw. steam turbines at that point. Had the cement plant been contemplated originally, more copper might have been used along the whole line, and more generating capacity installed to advantage. As an interesting illustration of the value of synchronous condensers in connection with transmission of electric power, it may be stated that while delivering a distributed load of 1000 kw. between the intake and the Pinto hills, 400 to 420 kw. could be delivered at the cement plant, 125 miles from Cottonwood at 30,000 volts with 35,000 volts at Cottonwood when not in parallel with the steam turbines; and that 800 kw. can be delivered at the cement plant when running in parallel, by strengthening the field of the turbo-generators, with the same voltage drop and the same distributed load along the line.

There are about 74 step-down transformers connected to this line in banks of two or three; most of these transformers are of 40 kw. capacity, the remainder are either 20 kw. or 80 kw. The greater number are of the out-door type, which have given excellent satisfaction, and are very much liked by the men in charge of work, because of the decreased expense and time of setting them up. Most of them have been shipped from the factory with the oil in them, as they are in boiler iron cases, made suitable for moving with the oil in place, thus avoiding the necessity for drying out of transformers at isolated places. The protection of this high-tension line against lightning and surge voltages is a combination of low-equivalent arresters at the Cottonwood power house and three sets of horn-gap arresters at other important places. The transformer stations are protected by air-insulated choke coils and fused horn-gap switches. The comparatively small insulators for the voltage used, while they have given no trouble whatever, do undoubtedly serve to give additional protection to apparatus along the line by affording relief from any excessive potential. No apparatus has been lost from lightning or surges during the eighteen months of its operation.



33,000-Volt Portable Sub-Station—outdoor type transformers.

By including interest, placing a proper depreciation on the permanent power plant, and assuming a low value of return from the copper on the temporary line, and on the transformers constituting the sub-stations, (the system to be in use but four years), it was estimated that the cost per kilowatt hour delivered at a step-down voltage, in large and small quantities

as desired, would be approximately 1.15 cents. The indications are that this estimate will prove to have been conservative.

Uses of Electric Power.

Stating as briefly as possible the uses to which this power is put; there are in Owens valley about 20 miles of the aqueduct which can conveniently be built with dredges. Four electric shovels are in use for conduit excavation in the open country. One mill for regrinding tufa with the cement is located at Haiwee, 22 miles south of Cottonwood. Electric power is used at Haiwee, also for sluicing and other work connected with the building of the earthen dam. There are approximately 18 miles of rock tunnels and three miles of earth tunnels provided for by this power system. The typical tunnel equipment consists of one air compressor, driven by a 100 h.p., 440-volt, three-phase induction motor; one 80 kw. motor-generator set, providing 250-volt direct current for electric locomotives; lighting and other work inside the tunnels; other power for blowers, machine shop, hoists, pumping, etc., as the case may be, and for lighting camp. In case electric locomotives are not used, as in shorter tunnels, alternating current at 110 volts is used for lighting in the tunnels also.

Dredges. There are two suction dredges in operation in Owens valley, each equipped with a 12-inch centrifugal pump, driven by a 100 h.p., 440-volt induction motor; one 40 h.p. motor to run the cutter, one 40 h.p. motor to run the jetting pump for breaking down the bank over the cutter, and one 20 h.p. motor for operating various hoists. There is also one dipper dredge of one and one-half yards capacity of the friction type, driven by one 100 h.p. induction motor. The step-down transformers in each case are mounted on a float, with the rack overhead supporting the choke coils and switch on which the taps from the transmission line land. The line being close by requires but one short span, and a crossarm is placed on the round cedar pole by clamping it with two bolts and a short piece on the back, and then safety is insured by pushing up at a safe distance from the lower arm. Connection is made with the line through long spiral springs of tempered brass and a brass slip at the end. These are put in place by means of a long pole from an insulating stand, or by climbing a short distance up the power poles, with the line switches at the transformers open, and the transmission line hot, which necessity requires, and which cannot result in personal harm when done by an experienced lineman, as is the case. The connection from the transformer float to the dredge is made by means of a three-conductor submarine armored cable. The cable is stored on a reel on a second float attached behind the dredge, with flexible connections to the dredge, so that the cable is automatically paid out, and when all out the flexible connections are detached and the cable wound up, then the reel float and the transformer float are towed up to the dredge together. This method has proved very satisfactory in avoiding abuse to the cable and in saving time and expense in moving.

Electric Shovels. Electric shovels with three-quarter yard buckets, and 25-ft. booms, used for conduit excavation, are of the friction type, driven by one 75 h.p., 2200-volt induction motor. The step-down transformers are mounted permanently on sleds or trucks, with the racks supporting the choke coils and switches permanently fixed overhead, and with two 10 kw., 2200 to 440-volt transformers attached, supplying power for concrete mixers operated in connection with each shovel. The cable used is three conductor No. 10 with rubber insulation, rounded out with jute, taped with weather-proof braid and half round steel armor over all. This connects between the transformers and the shovel and between the temporary 440-volt line on the power poles (about 1000 ft. back from the transformers) and the mixers, and is giving excellent satisfaction. The considerable advantage experienced with the use of out-door type transformers in connection with dredges and shovels is very evident.

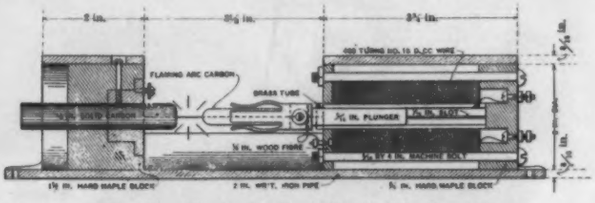
Electric Locomotives. Twelve three-ton electric locomotives rated at 1200 lb. draw-bar pull at six miles per hour are in use in this section of the aqueduct. At each end of the Elizabeth tunnel, which is not supplied from this power system, there is one locomotive of this size and one six-ton locomotive. In that tunnel ,which is approximately 90 sq. ft. in section when lined, the larger locomotive is preferred, making it possible to pull out 14 to 16 cars of muck at one time. The three-ton locomotives are of good size for the tunnels in the section under consideration, which are approximately 70 sq. ft. in finished section, and range from 2000 to 10,000 ft. in length where locomotives are used. The use of electric locomotives in these tunnels results in a reduction in cost of excavation and placing the concrete lining, which is a considerable percentage of their total cost. The actual cost of removing muck and delivering concrete is considerably less than it would be if done in other ways, especially by mules; but the greater reduction in cost is due to the practical condition of being able to get the muck away for the convenience and economic working of the miners in excavation, and allowing the placing of rock crushers and concrete mixers at a convenient point outside of the tunnel for concrete work. Concreting is being done successfully and with perfect satisfaction to the engineers at a distance of 10,000 feet in one instance. This use of these machines makes it possible not only to reduce the cost where speed is not a consideration, but to very materially increase the speed, if desired.

Small Isolated Power. Experience with distillate engines in connection with concrete mixers and other small power has led the men in the field to plead for electric power; for example, several steam shovels are in use in this section for conduit excavation, and it was thought at first that the expense of stepping down the voltage, moving transformers, etc., for supplying two or three motors of 7½ to 10 h. p. each would not be justifiable but the division engineers now insist that the cost of maintaining and operating distillate engines under the conditions experienced along such work is in itself greater than the cost of supplying the electric power, including the charge made against them for the energy, as well as the equipment, beyond the transformers; and they further state that the interruptions which they have experienced in concrete work with distillate engines behind a single steam shovel, as compared with what they have experienced in concrete work with electric

power behind an electric shovel, has cost them anywhere from $20 to $40 a day after the engines had been in use a few months and began to develop troubles under those conditions of operation; in other words, the saving is due to the consideration of reliability aside from actual cost of supplying power to the mixers. The cost for tunnel work is considerably reduced and the speed increased by electric lighting.

Protection Against Gases.

One of the long tunnels in another section runs through an oil district, and at times has developed considerable explosive gases. In order to protect the men against this danger, electric sparking devices have been installed, designed as shown in the illustration. They may be operated either by alternating or



Sparking Device for Exploding Gas in Tunnel

direct current. They are operated by direct current in this case by means of a switch outside of the tunnel, and as may be seen, are absolutely positive in their action and cannot fail if properly trimmed when the miners leave the tunnel. They have exploded gases several times, and in the form shown are usually found intact after the explosion; several of them being in use gives opportunity for further trials before entering the tunnel.

Telephone System.

The telephone system is considered not only one of the most profitable adjuncts to the aqueduct construction, but one which is essential to its economic construction at reasonable speed. It consists of approximately 260 miles of main line from the Los Angeles offices to the intake, built of two No. 10 copper wires strung on redwood poles, at a cost of $188 per mile. This line is divided in three sections by two exchanges, which more than doubles its efficiency. In addition to this there are local telephone systems in each of the various divisions along the work; some of these have as high as 26 telephones. Each local system may be temporarily connected with the main line by a switch in the division engineer's office, there being but one main line telephone on each division. As the telephone system is to be used by all classes of men, very few of them familiar with electrical work, it was thought undesirable, if not wholly impossible, to operate it successfully with the line on the power poles. Estimates showed that by making the poles on the transmission line five feet shorter, the telephone line could be placed on separate redwood poles at an equal or slightly less cost, and this has been done. The telephone lines are in every case placed underground at crossings with high-tension electric lines.

Amount of Power Required.

A good idea of the amount of power necessary to operate the equipment may be obtained by studying the following tabulation, which gives the total rated motor capacity, approximately 3470 h.p., of the various equipment attached to this system, and the total electrical horsepower, approximately 2000 h.p., required at the switch board of the two power plants combined for supplying this system independent of the cement plant. The energy necessary for lighting machine shops and other small requirements is not tabulated, but is included in the power at the switchboard. In many instances power is used 24 hours each day, but in other cases during 16 or 8 hours per day; on an average about 16 hours per day. The amount stated as being required at the switchboard is taken from the heavy load periods during the day; in other words, the average peak load for that work. The average load during the 24 hours would be about 60 per cent of this.

Motor Installation Intake to Pinto Hills.

2	suction dredges	400 h.p.
1	dipper dredge, 1½-yard dipper	1000 "
4	electric shovels, ¾-yard dippers	300 "
	Tufa regrinding mill	200 "
	Haiwee dam, hydraulic work	100 "
8	air compressors, 500 cu, ft. each	800 "
8	motor generators, 80 kw. each	1000 "
7	rock crushers, 10 and 20 tons per hr. each.	140 "
28	concrete mixers, 6 and 10 cu. ft. per batch.	280 "
7	blowers, 1350 cu, ft. per minute each	70 "
3	hoists	60 "
2	pumps	20 "
	Total rated capacity of motors	3470 "

The average power used at each end of the Elizabeth tunnel, already described, is 88 kw. during the 24 hours, divided, as follows: 5½ kw. for lighting outside the tunnel; 35½ kw. for operating the motor-generator which supplies power for ventilation, electric locomotives, lighting the tunnel and a small amount of pumping from the tunnel; and 47 kw. for compressed air for drilling, machine shop, camp water supply, etc. The average peak is about double the average load.

JAPAN'S HYDRO-ELECTRIC POWER.

It is evident that the central government of Japan has recently come to appreciate the great value and importance of its water-power resources. Heretofore provincial authorities have granted certain water-power rights, but now the central government authorities have taken the matter into their own hands, with the intention of inaugurating a characteristic Japanese system of exact procedure in the conservation of the country's extensive hydro-electric possibilities. The promotion of industries and providing new means of raising revenue are here combined in advancing reasons why the government should inaugurate the new system of conservation.

There has been a rush for water-power rights throughout Japan, and it is now evident that the government proposes to restrict those who are presumed to seek franchises of this nature for purely speculative purposes. American capital is largely interested in hydro-electric enterprises in Japan, and under favorable conditions American capital is ready for large investment in extensive power plants.

THE DIRECT MEASUREMENT OF HIGH RESISTANCE BY A MEGGER.

BY ARTHUR J. ROWLAND.

No matter what the thing to be measured a direct method is always to be preferred. It is not only that the observation is made quickly and the result known at once, but the attention of the observer is fixed on the result he is securing and not taken up with calculation or manipulation in trying to arrive at an intelligent conception of the magnitude of the thing about which he wants to know. There was a day when galvanometers were used for most measurements of current; but now ammeters are invariably applied to any sort of test where their range and accuracy can make them available. Years ago Thomson galvanometers were widely used for switchboard work; no one would think of such an instrument for such a use now. In these days engineers install watt-meters, power factor meters, frequency meters, etc., for the direct measurement of the quantity each can indicate rather than take the trouble to determine them by indirect means.

Among those things which must be known about and measured in dealing with electrical circuits, none is more important than resistance. Yet very little indeed has been done in the way of producing instruments for measuring it. We use volt meters and ammeters and compute it by the aid of Ohm's law; or we take a Wheatstone bridge for the measurement; or perhaps a voltmeter is employed for high resistance determinations. All of these involve indirect methods with well known limitations and faults. There are such things are ohmmeters, but they are scarcely used because the only instruments which have been available have such serious practical limitations that they are nearly worthless.

For high resistance measurements there has been no instrument available in the past except the Evershed ohmmeter which was made and sold in this country for a number of years. It was never much used, probably on account of the various serious inherent defects only too well understood by the inventor; and he turned from it to a prolonged search for a method of building an ohmmeter which should have very much higher sensibility than anything which had been produced before, be dead beat, have a good scale, and be reliable in calibration. He found this in an instrument of the permanent-magnet-moving-coil-type; a true ohmmeter but one with sensibility great enough to make it possible to read directly in commercial instruments of various ranges from an upper limit of 2000 megohms down to 1000 ohms. This instrument is the megger. Its general appearance is shown in Fig. 1. The author's experience with it makes him ready to assert that it is a remarkable instrument in sensibility and accuracy, while it has also wonderful ruggedness. It has revealed to him a great many things which are comparatively unknown regarding high resistance—particularly insulation resistance.

Measuring Insulation.

The measurement of insulation resistance has an importance which seems not to have been properly recognized. People have become so taken up with breakdown tests for determining the reliability of insulation, that the feeling seems to have crept abroad that failures on lines and cables and machinery (particularly for high voltage work) are due to disruptive breakdowns; that a fault suddenly develops, or a breakdown comes by a direct arcing discharge puncturing the insulation. The fact seems to be overlooked that frequently insulation deteriorates gradually, and along with it the leakage current rises through the diminished insulation resistance until at last the local heating and charring brings a time when away goes the whole structure when a vast increase in current occurs, through what has at last become a good conducting path. Breakdown tests are not applied except at the time of acceptance of a piece of apparatus, and anyone who has had experience with them know how unsatisfactory they are. One cannot tell

Fig. 1. The Megger (one-sixth full size).

whether the insulation has all but gone from permanent strain, nor whether under a different set of conditions a breakdown might have occurred. No one would dare subject new apparatus to a breakdown test until he knew its insulation resistance was sufficiently high. The man would not be considered sane who subjected his dynamos or cables to a weekly high voltage test to determine their security for the next succeeding period.

A megger can be applied as often as one pleases to measure insulation resistance without the possibility of any harm coming to the apparatus under investigation, and it may even be an important auxiliary when breakdown tests are contemplated. Take a single example. An oil insulated high voltage transformer is to be installed. Before the oil is put in, the transformer must be dried; because dry insulation and dry oil are essential to satisfactory dielectric strength. Moisture has a wonderful effect in lowering insulation resistance; hence, by the use of a megger it is easy to tell whether much moisture is present, and as the drying operation goes on how effective it is when the insulation has become dry. Or, suppose the transformer is an air cooled type now becoming old. Is it safe to keep it in operation or should repairs be made? A record of insulation resistance taken from time to time would make it possible to tell about this.

Figures 2 and 3 show the interior of the megger.

Fig. 2 shows clearly the permanent magnets so placed that a nearly closed magnetic circuit is formed. At one end is a dynamo armature in which, by turning the crank, the e.m.f. necessary to operate the instrument is generated. At the other end is the mechanism, more clearly shown by Fig. 3, by means of which the indications of the instrument are secured.

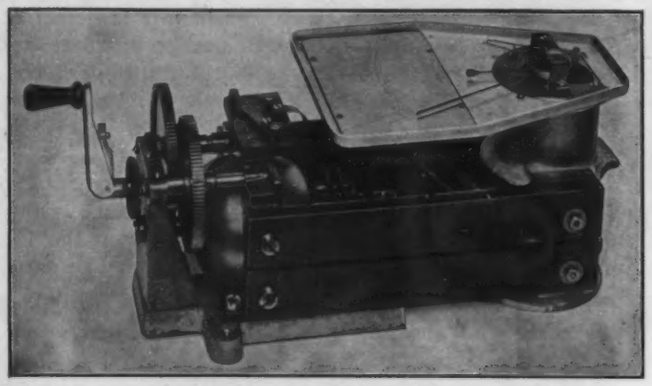


Fig. 2. An Interior View.

In Fig. 4 the magnetic circuit is shown diagrammatically as well as the internal connections of the instrument. When a resistance measurement is to be made the apparatus under test is connected between the binding posts marked "Line" and "Earth" (Fig. 1), or at the point marked "External Terminals" in Fig. 4. The crank is then turned at a convenient speed and the scale reading taken.

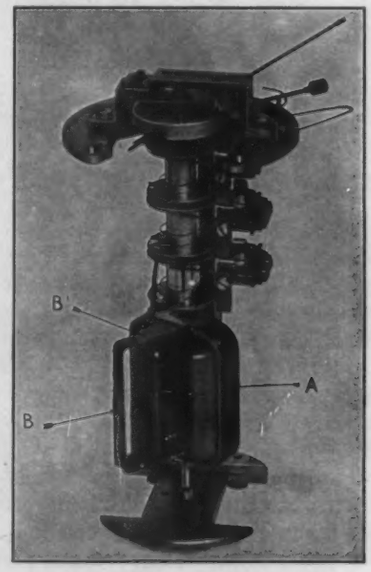


Fig. 3. The Moving System.

A brief explanation may serve to show how the instrument works and that it not only is a true ohmmeter but more true to calibration than most direct reading instruments.

The moving system consists of a coil marked A (Figs. 3 and 4), which is in series with the thing to be measured; and a pair of coils connected in series, marked B and B', which with resistance R are connected directly across the dynamo terminals. All three coils are rigidly connected together as indicated in the cuts and current leads are provided as shown in Fig. 3, where very slender copper strips may be seen hung loosely around small spools. These strips oppose a negligible restraining force. There are no springs in the instrument and the needle is liable to stand anywhere along the scale when the dynamo is not in operation. When the crank is turned and an e.m.f. acts, a current flows through coils B B' proportional to it. Suppose nothing is connected between the external terminals. The current in coils B B' drives them to a position where the least flux from the permanent magnet field is through them; that is, directly opposite the gap in the C shaped iron piece about which coils A and B' move. The needle then stands over the line marked "Infinity" on the scale. If now something having suitable high resistance is connected to the external terminals, current flowing in coil A produces a deflecting torque toward the position in which it is shown in Fig. 4; and as the system moves the coils B and B' exert a stronger and stronger restraining torque. Hence a definite position is assumed by the system and needle for the particular resistance connected.

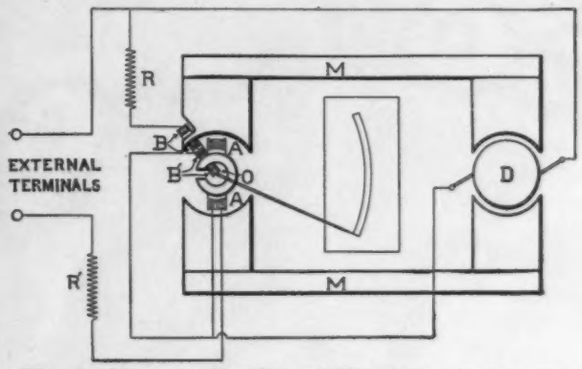


Fig. 4. Magnetic Circuit and Electrical Connections.

The instrument is a true ohmmeter, since an increase in the e.m.f. would increase the current in both coils the same proportionate amount, and the position of the needle stay fixed. It is dead beat; for the same means are taken to produce this result as in most instruments using a moving coil in a permanent magnet field, and fine results are obtained. It is also constant in calibration because deterioration of magnets can no more influence the position of the needle for a given resistance under measurement than a change in dynamo e.m.f. Time can have no appreciable effect since the case is not only dust proof, but the moving system is completely enclosed in an aluminum casting where neither dust nor moisture can reach it.

When measuring apparatus having considerable capacity, it is necessary to have a fixed e.m.f. so that charging and discharging currents shall not distort the reading of the instruments. This is provided by a friction clutch interposed between the armature and the driving gears. Above slipping speed of this clutch the dynamo e. m. f. is constant within half of one per cent.

The instrument, although made in England for several years and widely in use there and on the continent in much important work by the best of engineers, has hitherto been scarcely known in America. Complete information regarding it may be obtained from J. G. Biddle, 1114 Chestnut Street, Philadelphia.

BURNING FUEL OIL ON SHIPBOARD.

The following notes on oil burners are condensed from a paper on "Fuel Oil Installations and Tests Made on U. S. S. 'Cheyenne,' " by F. F. Ingram, published in the May, 1910, Journal of the American Society of Naval Engineers. This is published as supplementary to the series of articles on "California Fuel Oil" which are being written by R. F. Chevalier and in which details will soon be given of all other makes of Pacific Coast oil burners besides the two herein described. Mr. Ingram's advocacy of the outside mixer as compared with the inside mixer is open to a discussion for which the columns of the Journal are freely offered.

There are a great many devices on the market for burning fuel oil. The oil found in California and many western States contains an asphaltum base, which makes it impossible to use mechanical burners, because the asphaltum and carbon are readily deposited when the oil is highly heated and close the small appertures in the mechanical burners, necessitating frequent cleaning and removing and causing a fluctuation of steam and a great deal of annoyance to the attendant. With Pennsylvania and Ohio oils this difficulty is not experienced, as paraffin is the base, and superheating the oil assists its combustion.

The type of burner used on the Pacific Coast is adapted to both paraffin and asphaltum bases, two general types of burners being used—an outside mixer, or atomizer, and an inside mixer, or vaporizer. Both have their relative merits and deserve mention.

The outside mixer or atomizer is simple in construction. There are no parts to get out of order, and there is no internal deposit of carbon and asphaltum in the oil passage, the oil being kept under pressure until it reaches the combustion chamber, when it is released at right angles to the atomizing agent in the open combustion chamber. No adjusting of parts is necessary except to vary the amount of oil to suit the load being carried. With outside mixers the oil and atomizing agent do not come in contact with each other until they reach the combustion chamber, and a small percentage of water in the oil does not interfere materially, as the water contains enough oil to keep the burner lighted. The oil being superheated to 230 degrees in the burner immediately evaporates any water that is held in suspension in the fuel oil. With outside mixers there is no sputtering or series of explosions, so objectionable and annoying to the attendant.

Fig. 1 shows an outside mixer or atomizer of the type used in the U. S. S. Cheyenne. This burner has given very good results. The oil is kept under a constant pressure of 50 pounds and the atomizing agent at 70 pounds. The oil passes through a heater that has a steady pressure in its jacket of 50 pounds per square inch. The temperature of saturated steam at 50 pounds pressure equal 281 degrees F., consequently the oil is kept at a high temperature. It is further heated by passing through the superheater 3, in the burner, where the atomizing agent surrounds the oil. This further adds to the already superheated condition of the oil, and upon being released in the combustion chamber at right angles to the atomizing agent it instantly becomes a gas and burns with a soft, white incandescent flame, almost noiseless except when being forced. Fig. 2 shows the head of burner. When the oil is delivered through the small hole 5/32-in. in diameter, the oil is retarded by the baffle plate 1, and forced through the circular passages into the annular opening 4, where the atomization agent comes in contact with the oil; a handle is also fitted to these burners to facilitate handling when hot. After being placed in position the handle is detached. To clean these burners, remove the baffle plate and clean the obstruction from the circular grooves; with good oil these burners do not require to be changed for weeks.

The U. S. Tug Navajo is fitted with the Ingram type of outside mixer or atomizer, and on a recent trip from San Francisco to San Diego, a distance of 500 miles, these burners were not removed from the furnaces nor did they require cleaning during the entire

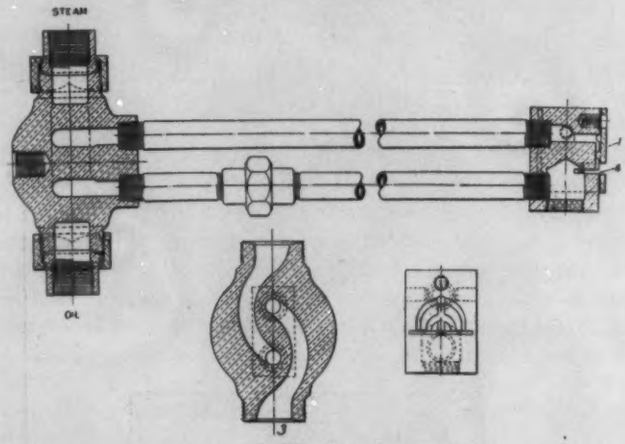


Fig. 1.

trip. Steam was maintained at a steady pressure and smoke was not seen during the trip, showing that combustion was perfect. The U. S. Tug Umatilla and the U. S. Monitor Cheyenne, also steam launch and galleys, are equipped with Ingram burners. Coal was not used on the U. S. S. Cheyenne for four months previous to going out of commission at Mare Island.

With inside mixers or vaporizers the steam or other atomizer comes in contact with the oil in the internal portion of the burner. The oil is contained in a pipe 3/8-in. diameter inside of a pipe 1 in. in diameter. The steam surrounds the oil pipe, therefore heating it to a very high temperature. The oil passes out at the small holes in the mixer where it comes in contact with the steam. It passes through to the mixing space where it is given a circular motion by rifling in the mixer head. Then it passes to the burner tip and is admitted into the combustion chamber in the saturated condition. A soft, white incandescent flame is the result. With careful regulation the inside mixer gives excellent results, but when forced it has a tendency to smoke and show a red flame, because more oil is being admitted to the burner than it can vaporize. There are many parts to the inside mixer which require a certain amount of skill to take apart and put together again. An objectionable feature is the packing in the burner, as the high temperature of the metal has a tendency to burn the packing, thereby causing it to leak steam into the oil passage. Care

must be exercised with inside mixers, as any increase or fluctuation in the pressure changes the mixture of the gas and causes it to go out or to sputter or give off a series of explosions, giving notice that it needs attention.

With inside mixers water in the oil has caused annoyance, and it has been proven that oil containing 1 per cent of water cannot be burned with inside mixers without giving a great deal of trouble and smoke, sputtering, and finally going out. In another boiler using the same oil, same atomizing agent, same conditions except that an outside mixer was installed, no change seemed to occur except that the oil valve had to be opened a little more.

An inside mixer type of burner of the Staples & Pfeiffer design has been used constantly on the Pacific Coast for a number of years and given excellent results. Troubles encountered with this type of burner are not always due to the burner, but in many cases due to faults in other parts of the installation. Great care should be taken to see that an excessive amount of air does not enter the combustion space, causing an undue amount of waste by heating the surplus air. Too little air will be easily detected by the furnace showing a dull red flame, indicating that not enough oxygen is supplied to consume the gases.

Advantages of Oil Firing.

With fuel oil a steady pressure can be maintained and hence more uniform and efficient results obtained at the engine than with coal. With coal it is necessary to open the furnace doors at short intervals to allow for coaling, slicing, raking and cleaning fires, causing a fluctuation in the steam pressure, besides allowing a great rush of cold air to strike the heated tubes, which produce unequal strains on parts of the boiler exposed to the cold air, thus causing the tubes to warp and bend and even leak. With oil fuel it is not necessary to open the furnace doors, as peep holes are provided in the furnaces over each burner, enabling the attendant to watch the burner.

It is desirable in ships of war to get up steam in a hurry. On one occasion a boiler was connected up in 26 minutes from cold water. There is also the advantage that on cutting a boiler out or securing boilers, when fires are extinguished the fuel expense ceases and the boiler ceases to steam. Valves can be closed and ash-pan secured, damper closed, there is no further trouble; no fires to haul, no ashes to care for and get in bilges to stop up strainers; no grate bars to renew; no tubes to sweep, nor paint work to scrape when coming to anchor. With oil all such worry and labor is avoided and the labor for coaling ship is reduced to two men. With oil a hose is led to the filling valve on the outside of the ship, the pump is started and a manipulation of the valves is all that is necessary. Three hours is all that is needed to supply 1485 barrels of oil, where in a former commission it required the ship's company all day to take on 388 tons of coal, besides a whole day to scrub and clean ship and the next day for the men to remove the coal and dust from their bodies and clothes.

Installation.

There are no given or set rules for the bricking or arrangement of the interior of the furnaces. With tubular boilers the custom is to have the grate bars in and construct a blind wall under the front row of grate bars, near their further end to prevent the air from passing into the back connection. The grate bars are covered with a layer of fire brick. A few bricks are omitted directly under the burner to allow of sufficient air to pass in for combustion. It also tends to superheat the incoming air.

With water-tube boilers the usual practice is to remove the grate and bearing bars and construct a bridge wall in front, with occasional holes to allow sufficient air to pass to the combustion chamber. In large combustion chambers pyramids of open brick work are often constructed, as they assist combustion by giving off a glowing heat. No general rule can be followed for installation, as conditions vary. Chimney heights have to be taken into consideration. Baffling and bricking should be done to suit the individual plant.

A great deal of fuel is needlessly expended in smoke and on account of defective installation. When insufficient air is supplied a certain amount of gas must pass off unconsumed into the atmosphere in the form of smoke. If we could remove the carbon and sulphur from the smoke we would have smokeless burners. Uusually it is the fault of the installation, and not the burners, that causes smoke. If the burners are turned down sufficiently, so as to eliminate smoke, you may know that the supply of air is nearly right, but this will produce a drop in the steam pressure, as the oil must be turned on smoke or no smoke. Many plants are installed without regard to economy because a contract has been awarded to the lowest bidder, and he in turn installs the plant in the most convenient manner to suit his own pocket-book, regardless of economic results. A certain evaporation efficiency is usually guaranteed per pound of oil, but few plant owners care to go to such trouble or expense to prove the truth of this boasted guarantee.

A reducing valve should be installed on the steam line leading to the burners, thereby causing steady and even pressure at the burner. With the boiler pressure on the burner a slight fluctuation in the pressure causes a change in the adjustment. After months of experimenting at different pressures on oil and steam, a constant pressure of 70 pounds on the steam and 50 pounds on the oil gave good results, and these pressures were adopted by the inventor. After the burner is once adjusted to the load no further adjustment is necessary.

All fittings on pipes 3 ft. and up should be made with screwed flanges beaded over into a counterbore. Gaskets of rubber should not be used, as the oil dissolves the rubber and causes leaky joints. A piece of No. 1 canvas shellaced on both sides and made up wet will never give any further trouble. Seven threads on all piping where oil passes through should be made up with shellac. Means for getting rid of an accumulation of water in the oil should be provided, as water causes sputtering and intermittent explosions.

Foreign substances in the oil cause a lot of annoyance to the attendant. Strainers or filters composed of fine gauze wire around the basket of the strainer, and placed so as to be easily gotten at to clean these strainers, should be on the discharge line from the fuel-oil pump to the burner. Magnesia and dirt are hard to

burn and are prime factors in plugging up the holes in the burners.

A separate line should be employed for filling tanks and double bottoms on ships, thereby not interfering with the suction from any tank. The suction line should be placed as low down as possible, and the pumps should be installed in such a manner as to prevent any great lift on the suction side. Means should also be provided for proper ventilation of all tanks. Vents should be carried sufficiently high so as to avoid ignition of vapors. Gate valves on all suction lines prevent undue friction, as they can be opened to their full area. Globe valves are not so well adapted to oil as gate valves, as cold oil flows sluggishly. Restricted areas and short bends in pipe and fittings cause undue friction, thereby retarding the flow of oil. Ships that cruise in Northern latitudes are fitted with a steam coil in their fuel tank, so as to assist the pump in delivering the oil to the burners by rendering it more fluid.

Great care should be exercised in regard to leaky joints, as disastrous results might occur from an accumulation of gas in bilges and bunkers. The oil lines in the fireroom space should be examined once each week for leaks. Great care should be taken around the furnaces while changing burners to see that no oil valves are left open. Burners should never be allowed to remain in dead or cold boilers, as the oil valve might accidentally be opened, causing the oil to flow into the furnace unnoticed; a formation of gas and an explosion might be the result of someone's carelessness. The usual method is to have a rack. When the burners are removed from the boilers they are cleaned and placed in the rack, where they remain until required for use.

Combustion of petroleum, like that of all gaseous fuels, can be carried on with a much higher degree of efficiency than that of solid fuel. While the calorific value of 1 pound of oil is as 1.37 to that of a pound of bituminous coal, and 1.63 to that of a pound of anthracite coal, in actual practice it is found that one pound of oil is fully equivalent to 1.8 pounds of coal.

There are three further advantages in the use of oil apart from the direct cost of fuel. First there is the economy of labor in attendance at the boiler, owing to the larger consuming capacity of a boiler, because the heat is applied continuously without any interference or interruption compared to that of applying the coal on a furnace of an ordinary boiler, then there is the absence of smoke and cinders, or waste of any kind, compared with the smoke and ashes and refuse left from coal; and lastly, the cleanliness and ease of manipulation at the furnace.

In oil-fuel burning a high furnace temperature gives more perfect combustion, and it requires less force to atomize the oil. With a properly arranged furnace, very little steam or air pressure is necessary for atomization, because the heat from the glowing brick work immediately converts the petroleum into an oil gas, and sufficient oxygen being admitted to the furnace is all that is necessary for complete combustion. The ash pan should be arranged with a door that could be adjusted to suit the amount of air necessary for combustion, which can easily be seen by an experienced fireman. A clear, white, incandescent flame burning up to the tip of the burner denotes proper combustion. Means should be provided to heat the incoming air before coming in contact with the oil gas. Different methods are used to obtain these results, but general practice will determine the most suitable arrangement for each individual installation, as conditions differ in most plants that were originally equipped for coal.

Smoke consists of the combustible and incombustible products evolved in the combustion of fuel oil, and is composed of such portions of hydrogen and carbon of the fuel gas as have been supplied or combined with oxygen, and, consequently, have not been converted into a carbonic acid; the hydrogen so passing away is invisible, but the carbon, upon being separated from the hydrogen, loses its gaseous character and returns to its elementary or organic condition, that of a black pulverized carbon, and as such becomes visible and passes up the stack in the form of unconsumed carbon, or smoke. Carbon dioxide is the result of perfect combustion; carbon monoxide is that of imperfect combustion. One pound of carbon combines with 2.5 pounds of oxygen and produced 3.5 pounds of carbonic acid.

An insufficient supply of air causes imperfect combustion and causes the unconsumed gases to be given off in the form of smoke, while an excess of air causes a waste of heat.

The volatile products of oil gas in the furnaces are "carbureted hydrogen" and olefant gas, which, upon combining with the oxygen of the air, becomes carbonic acid.

Theoretical or complete combustion teaches us that for every atom of carbon and for every atom of hydrogen there should be at least one atom of oxygen brought into contact with each other, and then subjected to a temperature sufficiently high to ignite them. The only way carbon can be burned is by diffusion of the gases, whereby the molecules are brought into close contact with each other. But this diffusion requires time, as the gases are constantly being cooled by the incoming air, and carried away by the uptakes before being sufficiently heated; and, not reaching the point of ignition, the particles pass up the stack in the form of dense black smoke. An excess of air entering the furnace is a waste, especially with fuel oil, as too much air cools the furnace sufficiently low to retard the proper commingling of the gases. The incoming air should, if possible, be superheated before coming in contact with the oil gas. A portion of the air is heated by coming in contact with the brick work inside the furnace, which, under ordinary conditions, is very hot. Therefore it is evident that with the fuel oil installation forced or induced draft is not to be considered economical, as the open furnace allows the incoming oil to flow to the combustion chamber with such velocity that the gases are cooled below the ignition point and pass off unconsumed. Only the gases that are deflected and baffled by a series of brickwork in the combustion space are ignited; consequently a large volume of smoke is emitted. A short, white incandescent flame indicates good combustion, as the cooled gases from perfect combustion are colorless.

Where it is possible for the diffusion of gases

to be completed before combustion begins, as in the Bunsen gas burner, these difficulties naturally disappear, and there is readily attained a short flame, which, moreover, is incapable of depositing soot even on a cold object. In the case of liquid fuel, which is incapable of vaporization, the diffusion and ignition must occur simultaneously. With such a fuel there is bound to be considerable flaming, and a long tongue of flame issuing from a burner with great velocity, will, sooner or later, prove disastrous to the back sheet of the combustion chamber. Where stay-bolt nuts are exposed to the flame they should be protected by porcupines held in place by set screws, or, what is still more desirable, a lining of fire brick. The point of the flame is always the hottest, and if it impinges on a tube or back sheet it will burn it. The flame being so intense, and the circulation in that portion of the boiler so slow, a film of steam forms between the tube or sheet and prevents radiation of the metal, thereby causing overheating and bulging of the back sheet of the combustion chamber, and, in many cases, in water-tube boilers the tubes become warped and bent due to the flame impinging on the tube. Several naval vessels have had tubes burned out on their trial trips due to this cause. These ships were fitted up with oil as auxiliary to coal, as has recently been the practice in the British navy.

The process of burning oil in this way in combination with coal cannot be considered satisfactory as far as combustion is concerned. The oil is sprayed on top of the bed of coal. The opening and closing of furnace doors allows a large quantity of air to enter the furnace, cooling down the gases already in the process of diffusion below their ignition point. Also the gases being distilled from the coal suffer from the volumes of excess oxygen being admitted to the combustion space. Great danger of back flaming while working the fire causes the firemen to neglect the fires to a great extent and allows holes to be burned in the back of the furnace, allowing free air to enter without passing through the fuel bed, thereby doing no useful work, but causing a waste of fuel and energy.

Settling Tanks.

Where oil is carried in double bottoms, and required to be pumped into settling tanks, some provision should be made for getting rid of the water precipitated. A convenient and safe method is to have a hand pump on the main deck connected from the bottom of the settling tank, and discharging into a funnel and carried overboard. Then when water accumulates in the settling tank it can be pumped independent of any pump that might be on the suction line to the burners. When the water is nearly gone oil will appear in the funnel, showing that the water has been displaced, and is a sign to stop pumping. In every oil-fuel installation special provision should be made for the removal of the water that will collect from various sources at the bottom of the settling tank. Even a small amount of water pumped to the burners will interfere with the efficient and satisfactory work of an oil-fuel installation.

As it is essential with every boiler plant to secure a uniform if not large output, the annoyance and evil of occasionally pumping water rather than oil to the burners cannot be overestimated. The trained and intelligent fireman can always tell when water is present in the oil; a slight sputtering and series of short explosions gives warning; if attention is not given the oil system the fire will keep going out. The trained fireman proceeds to drain his heater and get rid of the accumulation of water precipitated caused by the heating of the oil. Therefore it is apparent that more skill and intelligence is required to burn oil than coal. Cheap and careless help around an oil-burning plant is liable to prove expensive in the end.

THE ELECTRIC SERVICE OF THE PENINSULAR TOWNS.

BY LEE H. NEWBERT.

For business reasons the vast territory served by the Pacific Gas and Electric Company is cut up into more than twenty districts. These districts are roughly somewhat larger than California counties, and, like them, they vary in shape and area according to the lay of the land and the density of the population.

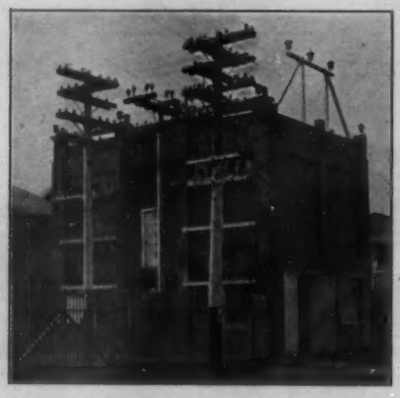
The railroad route about the southerly arm of San Francisco Bay roughly outlines a wish-bone. The joint of the wish-bone is the city of San Jose, down beyond the reach of the waters; the lobe at the end of one arm is the city of Oakland; and the lobe at the end of the other arm is the city of San Francisco. Along the peninsular arm, from the limits of San Francisco to the limits of San Jose, there is a valley and foothill stretch of territory about forty miles long and about five miles wide, gently sloping eastward toward the bay. Midway of this great suburban strip of live-oak country is Redwood, so called because half a century ago it was the center of a redwood lumber district, one old tree of which remains in the giant "Palo Alto," near Stanford University. And Redwood is the headquarters of the Redwood, or peninsular, district of the Pacific Gas and Electric Company's system. This Redwood district includes just a dozen communities: Belmont, with 600 people; Burlingame, with 5000; Easton, with 500; Mayfield, with 1500; Menlo Park, with 1500; Milbrae, with 300; Mountain View, with 2500; Palo Alto, with 6000; Redwood, with 3500; San Carlos, with 150; San Mateo, with 7000; Stanford University, with 2000; and Sunnyvale, with 2000—total, 32,500 people.

All the peninsular communities as far down as and including Palo Alto are supplied with gas manufactured at the Pacific Gas and Electric Company's great oil-gas plant in Visitacion Valley, known as Martin Station. A huge main more than twenty miles in length carries the gas supply to these communities.

But this article is chiefly concerned with the electric supply and how it is distributed. The great high-tension power-lines from the mighty hydro-electric plants up in the Sierras come down through the interior valleys and stretch high across Carquinez Straits. A southern branch extends through to Mission San Jose, and then goes on to San Jose and way down to Davenport and the city of Santa Cruz. From Mission San Jose a branch of this high-tension system comes up round the bay, through Redwood, and on into San Francisco. The pole line, with its big insulators, is a familiar sight across the marsh lands.

At Redwood there is an electric station. It serves two functions: It is the distributing station for sup-

plying the electric needs of the northern part of the peninsular district, and it is an important high-tension switching station. The second floor of the concrete building is devoted exclusively to high-tension wiring and switching. That long marsh land pole line carries two 60,000-volt lines from Mission San Jose round into San Francisco, and those two lines pass through the Redwood station, where the switching arrangement is such that either of the two lines coming into or going



The Station at Redwood

out of the station can be taken out of service temporarily to permit repairs or work on them without shutting off the current along the entire double line. The different high-voltage switches making this safety plan possible are placed in separate concrete compartments, the construction of which, like that of the entire building, is intended to reduce fire risk to the smallest possible factor.

When what is now the Pacific Gas and Electric Company came into possession, about eight years ago, of the gas and electric properties of the peninsula, the sub-station at Redwood consisted of a wooden-frame building, covered with corrugated iron. It was 20 ft. square and 24 ft. high. For equipment that building had simply four 200-kw., high-tension transformers (one being a spare held in reserve) and three high-tension Stanley air-switches. The 6000-volt secondaries were carried overhead to another frame and corrugated-iron structure housing a steam auxiliary plant and a secondary switchboard, which was a combination of marble, wood, open fuses and air-brake switches.

By 1906 business along the peninsula had so increased that the present two-story concrete station building at Redwood was ordered erected. It is 26 by 36 ft. and stands 28 ft. high. The high tension oil and disconnecting switches in the enclosed concrete compartments on the upper floor are operated from the lower floor by means of levers. And on the lower floor are the high-tension transformers. the switchboards, the regulators and other apparatus.

There are three 500-kw. transformers. They reduce the main-line current to 11,000 volts for transmission northward to San Mateo and other towns and southward to Palo Alto, Mountain View and Sunnyvale; and to 4000 volts for local distribution in Redwood and the vicinity. There are also three 100-kw. transformers to supply Redwood's local service. These smaller transformers are fed from the 11,000-volt lines coming from the high-tension transformers. The connection is such that if anything should happen to the Redwood station these smaller transformers for Redwood's local service could be instantly supplied through the 11,000-volt line from the Mountain View station. The 11,000-volt circuits are three-phase, and the local distributing circuits are three-phase, four-wire, 4000-volt.

Ordinarily the current all comes from the hydro-electric plants in the distant Sierras through either of the two three-phase 60,000-volt lines, which extend on to San Francisco. But if something should happen along the hydro-electric power line there is an emergency switching arrangement by which current may be turned on from the company's great steam-generating electric plant situated out beyond the Union Iron Works in San Francisco, or from the company's steam-generating electric plant at San Jose. So the peninsular towns cannot be deprived of electricity except through some rare combination of accidents putting several mountain and two city plants temporarily out of commission.

The growth of peninsular population following the San Francisco fire was rapid, and early in 1907 it became evident that the existing electric system of the United Gas and Electric Company (a subsidiary company of the Pacific Gas and Electric Company) would have to be completely reconstructed in order to meet the increased demand for light and power service. Briefly described, the system to be replaced consisted of a main high-tension sub-station at Redwood, with two-phase, 6000-volt lines extending southward fourteen miles to Sunnyvale and northward eight miles to San Mateo. At San Mateo two 100-kw. transformers were employed to reduce the pressure to 2200 volts for distribution to San Mateo and Burlingame.

The 4000-volt distributing switchboard. the oi switches being mounted on the left. At the left are the high tension levers.

After a thorough study of conditions it was determined, notwithstanding the existing high price of materials, to rebuild in such a manner as to give not only a greatly improved service, but also to meet requirements for some time into the future. Subsequent development in the peninsular towns has demonstrated that the decision was a wise one, as the electric load taken to-day exceeds that of 1906 by one hundred per cent.

The new peninsular system as laid out by the engineering department called for an additional high-tension station at Mountain View, eleven miles south of the existing station at Redwood. The Mountain View station was to be fed from the high-tension line then in course of construction and now supplying

Davenport and Santa Cruz. There was to be a secondary sub-station at Palo Alto and an enlargement of the secondary sub-station at San Mateo. These stations were to be connected by a three-phase, 11000-volt tie line, with current supply from either Redwood or Mountain View.

Two of the three 100-kilowatt transformers that supply the local service.

As a result of the work, which was completed in the summer of 1908, the system consists to-day of the high-tension station at Mountain View, which, under regular operating conditions, supplies service to Mountain View and Sunnyvale and to the Palo Alto sub-station; and of the high-tension station at Redwood, which supplies Redwood and the San Mateo sub-station. The switching arrangement is such that, when circumstances require, either the high-tension station at Redwood or the one at Mountain View can supply the entire peninsular district.

The Mountain View station contains three 500-kw. oil-insulated, water-cooled, single-phase transformers, star-connected for 60,000 to 11,000 and 4000 volts; three 100-kw., single-phase, oil-insulated, air-cooled transformers; and the necessary switchboard and control apparatus. The high-tension oil-switches, like those at Redwood, are located on the second floor. The disconnecting switches are pole type, and are located on suitable structures outside. Voltage regulation is by hand, with two sets of regulators, one on the secondaries of the high-tension transformers and the other on the secondaries of the low-tension, or 4000-volt, transformers.

Service to Sunnyvale, three miles south of Mountain View, is through a three-phase, four-wire, 11,000-volt line. Mountain View service is three-phase, four-wire, and is regularly supplied from the 4000-volt transformers. When necessary, this service may be supplied from the 4000-volt taps of the high-tension transformers. Service transformers have voltages of 2400 to 220 or 110.

The Palo Alto sub-station is supplied through a three-phase, four-wire line. Service transformers are connected to supply consumers along the seven-mile line between Mountain View and Palo Alto. The Palo Alto sub-station contains three 250-kw., oil-insulated, single-phase transformers, 11,000 to 2400 volts; and the necessary switchboard, control apparatus and instruments. Voltage regulation is by means of two single-phase, automatic induction regulators so connected as to maintain a maximum voltage during the peak of the load. The secondary circuits are: Stanford University, Peninsular Railway, Palo Alto single-phase (for commercial district), Palo Alto poly-phase (for residence service), power, Menlo three-phase.

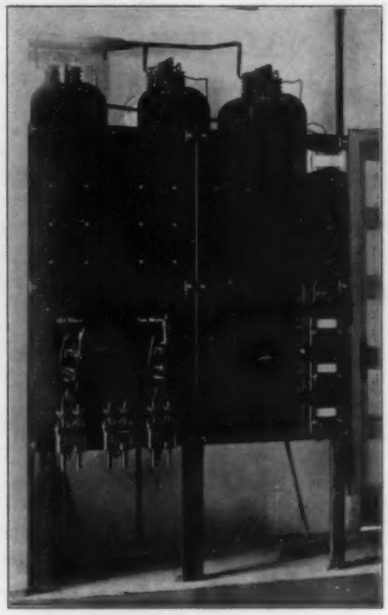
An 11,000-volt, three-phase, No. 4 copper, three-wire circuit extends from the Redwood station to the Palo Alto sub-station, four miles south, where it can be joined to the 11,000-volt line from the Mountain View station, when operating conditions require. Another 11,000-volt, three-phase, No. 4 copper, three-wire circuit extends from Redwood north eight miles to the San Mateo sub-station.

The local circuits from Redwood station are: Redwood lighting (single-phase, 4000 volts), Redwood power (three-phase, four-wire, 4000 volts), San Carlos and Belmont (three-phase, four-wire, 4000 volts), Fair Oaks (single-phase, 4000 volts), street lights.

The San Mateo sub-station contains three single-phase, 300-kw., oil-insulated, air-cooled transformers, 11,000 to 2400 volts, together with the necessary switchboard and control apparatus. Voltage regulation is by means of two single-phase, automatic induction regulators. The secondary circuits are: San Mateo single-phase (2400-volt for commercial district lighting), San Mateo poly-phase (for residence district), Homestead poly-phase, water works poly-phase, Peninsular Hotel poly-phase, Burlingame poly-phase, San Mateo street lights, Burlingame street lights.

In addition to the regular telephone service a private telephone line connects the stations at Redwood, Mountain View, San Mateo and Palo Alto.

All switching on the 11,000-volt line is directed by the Redwood station.



The 11,000-volt Switchboard (oil switches are in concrete compartments at the left).

The current supply to both high-tension stations is through duplicate lines from the Sierra power houses or (through the same lines) from the steam plants at San Francisco and San Jose. With the aid of the 11,000-volt tie line in case of accident at either high-tension station interruptions in service are doubly provided against, and the rare occasions when they do occur they last but a few moments.

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POWER AND GAS

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NOTICE TO ADVERTISERS

Changes of advertising copy should reach this office *ten days in advance of date of issue.* New advertisements will be accepted up to noon of Monday dated Saturday of the same week. Where proof is to be returned for approval, Eastern advertisers should mail copy at least thirty days in advance of date of issue.

Entered as second-class matter at the San Francisco Post Office as "The Electrical Journal," July 1895.
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FOUNDED 1887 AS THE
PACIFIC LUMBERMAN, CONTRACTOR AND ELECTRICIAN

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Measuring Instruments

The present hue and cry against defrauding the government with "fixed" sugar scales and cheating the ignorant poor by means of false weights and measures are popular manifestations of a general demand for precision. This insistence upon accuracy pervades every branch of business and is the fundamental requirement of all scientific work. Exactitude is fast superseding guess work and the definite formula is displacing the rule of thumb. To meet commercial requirements of rapid correctness there have been devised many ingenious instruments, such as the adding machine, computing scale, and cash register, which substitute mechanical for mental calculation. But, as science was the first to demand accurate measurement, so it has been the first to be supplied, and we now find many scientific instruments of precision being adopted for industrial uses.

Of these perhaps the most noteworthy is the adaptation of the laboratory galvanometer to the measurement of electric power. The watthour meter regulates the financial relations between the producer and the consumer and upon its integrity depends much of that desirable confidence which exists between the public and the corporation that serves it. Similar principles underlie many of the various switchboard instruments which control the operation of power plants. These include ammeters, volt-meters, both indicating and recording, together with frequency meters, power factor meters and synchroscopes.

For the laboratory, also, many new electrical instruments have lately been perfected with a range or a delicacy so great that it is now possible to measure phenomena which but a few years ago was difficult of even mental conception. Of such is the oscillograph, which give visible confirmation of the theory of alternating currents; also Professor Ryan's corona voltmeter and cathode ray indicator for observing high tension behaviors. Of equal value is the newly perfected megger for measuring insulation resistance, as described elsewhere in these columns.

Steam power plant economy has long required careful measurement of in-going fuel, air and water, and of out-coming power and waste, but it is only recently that these have been automatically determined by recording instruments from which the plant efficiency may be computed. Coal is delivered through an automatic weigher and oil is supplied, like air and water, through a recording meter. The amount of the flue gases, as well as their content, may be continually recorded for comparison with the weight of ash. A gauge tells of the maintenance of steam pressure and the recently perfected steam flow meter not only shows whether a boiler is delivering the proper amount of steam, but also indicates any leaks between the boiler and the engine, the performance of the latter being in turn checked by the indicator.

Many other examples could be quoted to show the increased industrial uses of measuring instruments, but enough has been said to indicate the trend of this movement, which will soon eliminate many of the old cut and try methods and make possible that accuracy which leads to true economy.

PERSONALS.

A. W. Fulton, an electrical engineer of Chicago, was a recent San Francisco visitor.

C. R. Downs of the water and lighting company at Sutter Creek, was at San Francisco last week.

H. B. Woodhill, of the Woodhill-Hulse Electric Company of Los Angeles, is visiting at San Francisco.

T. Meyers, an electrical engineer from the Island of Java, was a recent arrival at San Francisco.

W. P. Thomas, president of the Snow Mountain Power Company, was at San Francisco from Ukiah last week.

C. H. Coulter has succeeded H. P. Pitts, resigned, as purchasing agent for the Great Western Power Company.

E. B. Spalding, of Spalding, Sloan & Robson, San Francisco, has gone to Newman on electrical construction work.

W. B. Cline, president of the Los Angeles Gas and Electric Company, spent several days at San Francisco last week.

C. L. Cory has recently been successful in adapting electric motors to the requirements of the oil operators in the Bakersfield district.

F. A. Cressey, president and manager of the Modesto Gas Light, Coal and Coke Company of Modesto, recently spent a day at San Francisco.

D. B. Dean, representing the Kuhlman Car Company, after visiting Pierson, Roeding & Co. of San Francisco, left last Thursday for the Pacific Northwest.

H. E. Sanderson, Pacific Coast manager for the Bryant Electric Company, returned to San Francisco this week after a successful trip throughout the Pacific Northwest.

William Spalding, formerly with the Portland Railway, Light and Power Company, is now general manager of the Tillamook Electric Light and Fuel Company of Tillamook, Oregon.

James D. Schuyler, a hydraulic engineer of Southern California, who has been making engineering investigations in foreign countries for several years past, has arrived at San Francisco from Budapest.

Frank B. Hall, of Wheeling, West Virginia, and C. H. Judson are making an examination of the plant valuations and rates of the two telephone companies operating in Seattle for the Department of Public Utilities of that city.

M. de Chatelain, professor of the Polytechnic Institute and president of the Russian Imperial Technical Society, of St. Petersburg, recently spent a few days at San Francisco on a tour of the Pacific Coast, including a visit to the largest hydro-electric plants.

Hugh McPhee, formerly chief dispatcher and chief division operator of the Eastern and Kansas City division of the Western Union Telegraph Company, with headquarters at Emporia, Kansas, has been made manager of the main and branch offices of San Francisco, succeeding J. V. O'Brien.

John V. O'Brien, for years manager of the San Francisco city offices of the Western Union Telegraph Company, has been appointed special agent for the company for its First District, a territory comprising Northern California, Nevada and a portion of Arizona. He will have charge of the commercial business of the company under District Superintendent May.

Leon M. Hall, of San Francisco, has resigned as consulting engineer of the Comstock Pumping Association, after eleven years of faithful service. He had charge of the designing and installation of the famous electric pumping stations in the depths of the Comstock mines under conditions that required great skill and daring. Excellent showings were made as to efficiency. Major George Burbank, who represents the Probst-Wetzler banking interests behind the new United Comstock Pumping Association, has arrived at Virginia City as Mr. Hall's successor.

MEETING OF PACIFIC COAST GAS ASSOCIATION.

The eighteenth annual convention of the Pacific Coast Gas Association will be held at Los Angeles, California, September 20, 21 and 22, 1910, meetings being held in Choral Hall, Auditorium Bldg., Fifth and Olive streets.

The following papers will be read before the meeting: President's address, W. B. Cline; "Progress in Oil Gas Manufacture," J. M. Berkley; "Work Economies," Sherwood Crover; "The Municipal Inspection of Gas and Meters," Wm. Schade; "Gas Leakage," Geo. Kirk; "Relations With the Public," R. H. Ballard; "Necessities for a Public Service Commission in California," John A. Britton; "General Policy Regarding Pipe Extensions," C. A. Luckenbach; "Prevention of Accidents," J. P. Coghlan; "The Oil Situation From the Gas Man's View Point," H. W. Burkhart; "Suburban Distribution," L. H. Newbert; "The Introduction of the Gas Furnace," Charles F. Stamps, Jr.; "Fire Insurance and Protection," R. J. Cantrell; "The Chemical Control of Gas Works," E. L. Hall; "Wrinkles," Wm. Schade; "Experiences," Leon B. Jones.

Arrangements have been made with the Southern Pacific Company, the Santa Fe Company and the Salt Lake Company whereby the members attending the convention will be given a rate of one and one-third fare for the round trip (receipt certificate plan), and which plan will be in force for the period from September 10th to October 2d for all members attending the convention from points north of Mojave and Santa Barbara. Members attending from Mojave and Santa Barbara and points south thereof will have their certificates honored for return trip tickets up to and including September 26th.

The banquet will be held in the Hotel Alexandria on Wednesday evening, September 21st, at 8:00 o'clock.

Entertainments have been arranged as follows:

Thursday, September 22d, will be known as "Southern California Edison Company Day." At 9:00 o'clock a. m. the Edison Company will take the members of the association and their friends on an excursion to Soldiers' Home, Santa Monica, Ocean Park, Venice and Redondo. At Redondo luncheon will be served at 12:00 o'clock noon. Dancing, bathing and other entertainments during the afternoon. Returning to Los Angeles at 5:00 o'clock p. m.

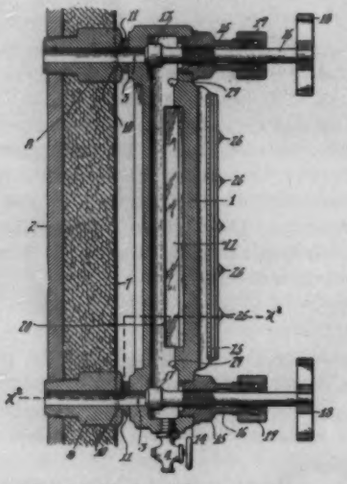
Friday, September 23d, will be known as "Domestic Gas Company Day." At 9:00 o'clock a. m. the Domestic Gas Company will take the members of the association and their friends on an excursion to Mount Lowe, where luncheon will be served at noon. Returning to Altadena at 2:00 o'clock p. m., automobiles will meet them for a trip through Altadena, Pasadena, South Pasadena, Alhambra, Eagle Rock Valley to Casa Verdugo (where light refreshments will be served), thence to Glendale, Tropico, Hollywood and Los Angeles.

Saturday, September 24th, will be known as "Los Angeles Gas and Electric Corporation Day." The Los Angeles Gas and Electric Corporation will take the members and their friends on an excursion through Watts, Compton and Wilmington to San Pedro, at which point steamer will be boarded for Catalina Island. Lunch will be served at noon at the Hotel Metropole, in Avalon.

It has been decided by the directors of the association to give an Appliance Exhibition. The Central Park Skating Rink, at No. 416 West Sixth street, has been secured for this purpose. Up to the present time more than twenty of the large manufacturers of appliances have signified their intention of taking space in this hall for the exhibition of their appliances. This exhibition will be open to all members and their friends, as well as the general public.

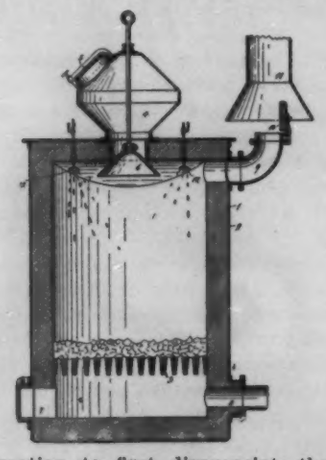
PATENTS

967,634. Water-Gage. George H. Goodwin, Los Angeles, Cal. In a duplex water gage, the combination with a jacketed boiler, of two hollow nipples therein, the outer end of each of which is provided with a seat, an elongated hollow body provided with two elongated sight openings set at an angle



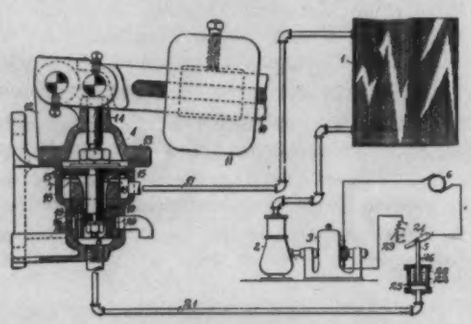
to each other and provided with a passage and perforated ears at each end, valve mechanism for controlling said passages, a perforated joint ring between each seat and a corresponding end of the body, and bolts through said ears and said jacket into the head of the boiler.

967,213. Process of Making Producer-Gas. Leon P. Lowe, San Francisco, Cal. The process of making producer gas which consists in passing air through an ignited bed of solid fuel to heat the same to incandencence and then passing oil and air into and through said incandescent bed in



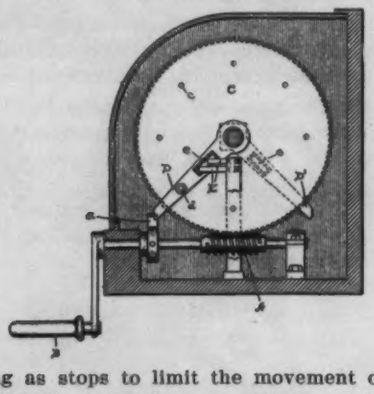
a downward direction, to, first, disassociate the oil into gases and heavy hydro-carbons, and then to convert the heavy hydro-carbons into gases and solid carbons, the latter combining with the air to maintain the proper temperature and assist in forming the producer gas in the usual manner.

967,234. Fluid-Pressure Regulator. Thomas S. Pufferud, Pittsburg, Pa., assignor to Westinghouse Electric & Manufacturing Company. The combination with a fluid-pressure tank or chamber, a fluid-pumping mechanism connected thereto, a driving motor for said pumping mechanism, a starting controller for the motor, and an operating cylinder and piston, of a regulator for automatically admitting fluid-pressure to and exhausting it from the operating cylinder to respectively start and stop the motor as the pressure in the storage tank or chamber rises above and falls below a pre-



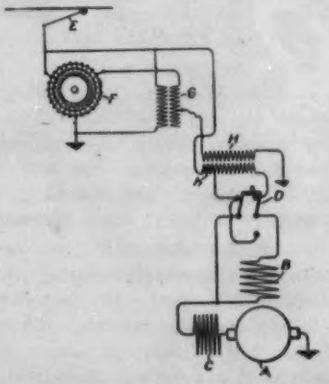
determined value, and means for compensating for the variations in the friction of the regulator.

967,171. Low-Speed Circuit-Controller. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company. A low speed circuit controller comprising a worm, a worm wheel adapted to be driven in either direction by said worm, two sets of stationary contacts, and two members carried by the



wheel serving as stops to limit the movement of the wheel in opposite directions and to engage the two sets of contacts respectively when the wheel reaches the two limits of its range of movement, said two members being relatively adjustable to vary the range of movement of said wheel.

967,295. Braking Alternating-Current Motors. Ernst F. W. Alexanderson, Schenectady, N. Y., assignor to General Electric Company. The method of braking an alternating current motor of the commutator type which consists in



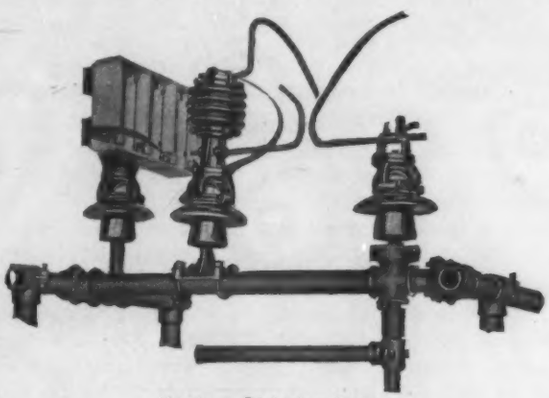
connecting the armature to the source and impressing on the field of the motor a voltage displaced in phase substantially ninety degrees from the voltage of the source and controlling the phase of said impressed voltage to vary the braking effect.

INDUSTRIAL

ALUMINUM LIGHTNING ARRESTERS FOR UNDERGROUND CABLES.

One of the most serious problems with which operators of underground cable systems have to contend is the protection of the cables against internal surges and against lightning in cases where the underground circuits are connected to overhead lines. During the past two years the General Electric aluminum arrester has been given a wide application in the protection of cable and mixed overhead and cable circuits, in fact has practically superseded all other forms and with its recent improvements is still better adapted for this class of service.

One characteristic of the aluminum arrester which has an important bearing on this application is the daily charging of the cells—a process which consists simply of subjecting the stacks of aluminum cones to the line voltage and short-circuiting the series horn gaps for a brief period. This charging process as well as normal discharges resulting from high voltage disturbances is accompanied by a slight arcing at



Aluminum Lightning Arrester.

the horn gaps. On cable systems where the electro-static capacity is large compared with the inductance of the circuit, it is advisable to take every possible precaution to limit the charging current to a minimum value.

In the General Electric aluminum arrester this is accomplished by means of a special horn gap used in connection with a charging resistance. The resistance limits the charging current and even if the cells are in poor condition smooths out the wave shape of the current and damps out any tendencies to oscillate. At the same time it does not prevent the cells from taking their full charge. These auxiliaries are so arranged as to give selective paths to the cells; one through a horn gap without resistance, which is the same as in the arresters for overhead circuits, and the other through a resistance and a horn gap, the setting of which is slightly less than that of the gap resistance. With this arrangement the daily charging current and the average surge discharge take the path through the resistance. This resistance is adjusted to a value which will so modify the nature of the charging arcs that there is no liability of resonance occurring. It also makes the charging more uniform and reliable.

Heavy discharges which will be impeded somewhat by the resistance will be shunted through the principal horn gap and have a free path without resistance. The arc from this discharge, rising on the horns, will be intercepted by the blade which is connected to the resistance and hence the current is limited at the end of the discharge and as the arc breaks. Thus surging which would be produced by the breaking of a large current arc in air is entirely elimiated by having the arc and current suppressed. Thus the safety horn gap with the charging resistance combines a number of valuable features in safety of operation without in any way decreasing the efficiency of the arrester as a protector of cable systems.

TWO TO THREE-PHASE TRANSFORMATION WITH STANDARD TRANSFORMERS.

It is frequently desirable to operate three-phase motors from a two-phase circuit. Almost any handbook or textbook will tell you that this may be done by using Scott transformation. The book will proceed to tell you that it is necessary to have the "three-phase coils of one transformer designed for 100 volts while the three-phase coils of the other transformer must be designed for 86.6 volts, or in that ratio." Such information is of but little value when a three-phase motor must be connected to a two-phase circuit, and connected in a hurry.

The accompaning diagram shows a connection which has been made frequently with standard Hawthorn transformers.

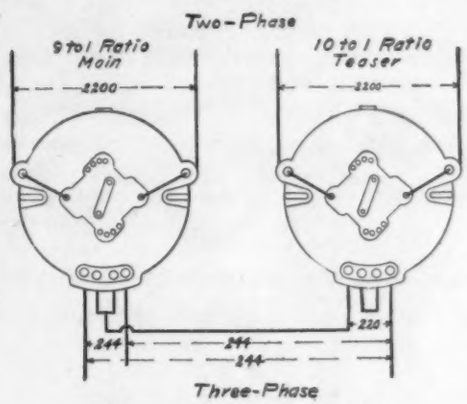


Diagram of Transformer Connections.

A 1100-2200 volt primary, 122-244 volt secondary, (ratio 9:1) transformer connected as "main" with a 1100-2200 volt primary, 110-220 volt secondary, (ratio 10:1) transformer connected as "teaser" may be recommended to operate a 220-volt three-phase motor on a 2200-volt two-phase supply. The secondary voltage given by this arrangement is 244 volts three-phase, but, allowing for line drop, etc., it is a satisfactory voltage on which to operate 220-volt motors. The unbalance and increase in heating are so small as to be negligible.

The Western Electric Company's Hawthorn transformers are well-suited to this work, the four secondary leads which are brought out on all of them, in order to make possible either of two secondary voltage connections, are a great convenience in making the two-phase to three-phase connections.

TRADE NOTES.

The F. B. Kellogg Switchboard & Supply Company have closed a contract for a switchboard at Grand View, Wash. in connection with the Benton Independent Telephone Company of Prosser, Wash. It is being engineered by Harry Miles at Prosser.

The Mexican-Northwestern Railway Company of 25 Broad Street, New York City, has recently placed a large order for motors with Westinghouse Electric & Manufacturing Company. The order includes 168 induction motors, aggregating 3736 h.p., of the types MS and HF, ranging from 3 to 200 h.p. These motors will be shipped to the company's property at Madera, Chihuahua, Mexico, to be used in the operation of the saw and planing mills.

APPROVED ELECTRICAL DEVICES

CABINETS.

Sheet Metal. Types J and K, also sectional Types G and H. Cast Iron. Type A. Approved Aug. 11, 1910. Manufactured by

H. T. Paiste Company, 32nd and Arch Sts., Philadelphia, Pa.

CONDUIT BOXES.

"Pipe-End" fittings, Cat. Nos. 1201-1204 incl., 1251 and 1252, with steel or porcelain covers. Approved, only for exposed work, July 1, 1910. Manufactured by

Arrow Electric Company, 630 Capitol Ave., Hartford, Conn.

"Pipe Taplets." Cast iron outlet boxes with threaded opening for standard sizes of rigid conduits. Types A, B, C, E, LL, LR, T, U and X. Also Cat. Nos. 4115, 4125, 4135 and 4170 for use with special porcelain covers or with suitable approved rosettes or receptacles. Approved, for exposed work only, July 20, 1910. Manufactured by

H. T. Paiste Company, 32d and Arch Sts., Philadelphia, Pa.

CONDUIT, MISCELLANEOUS.

Indurated Fibre Conduit. Approved, for use only in central stations and when laid in concrete for its entire length, July 18, 1910. Manufactured by

United Indurated Fibre Co. of New York, Lockport, N. Y.

CONDUIT OUTLET BUSHING.

"Burns" Entrance Hoods. Cat. Nos. 801-807 inclusive. "Burns" Terminal Fittings of the type of Cat. No. 911, etc., for conduit from ⅛ in. to 4 in. Approved July 22, 1910. Manufactured by

James F. Burns, 47 N. Hutchinson St., Philadelphia, Pa.

FLEXIBLE CORD, PORTABLE, FOR ELECTRIC HEATERS.

Double conductor cord. Stranded conductors with rubber and asbestos coverings. One type having single protecting braid over parallel pair of conductors; another type having single protecting braid over each of a twisted pair of conductors, and a third type having protecting braid on each conductor and a second protecting braid over the twisted pair of conductors. Marking: Yellow thread in cotton wind around copper strands. Approved August 8, 1910. Manufactured by

Safety Insulated Wire & Cable Co., 114 Liberty St., New York, N. Y.

GROUND CLAMPS.

A malleable cast iron fitting marked "T" for grounding gas pipe in conduit outlet boxes. Sizes for ⅜ inch and ½ inch pipes. Approved July 30, 1910. Manufactured by

Thomas & Betts Company, 299 Broadway, New York, N. Y.

HANGERBOARDS, ARC LAMPS.

"Perkins." Cat. Nos. 3221, 3226 (with plug fuse receptacles) and 3269 (with double pole ceiling switch and plug fuse receptacles). The switches are approved and labeled under the conditions previously stated. Approved July 20, 1910. Manufactured by

Perkins Electric Switch Mfg. Co., Bridgeport, Conn.

HEATERS, ELECTRIC.

"Johns-Manville" cylindrical heaters. Special Type H No. 1. Cat. No. 1566 for 110 volts. Cat. No. 1567 for 220 volts. A group of heat coils encased with perforated sheet metal and supported on iron legs. Supplied with regulating switch and approved heater cord for portables, for use on circuits up to 5,000 watts. Approved, when installed for use with suitable supply circuit, July 25, 1910. Manufactured by

H. W. Johns-Manville Co., 100 William St., New York, N. Y.

INSULATING SUPPORTS.

Glazed porcelain insulating knobs for supporting twisted pair telephone wires outside buildings and on poles. Cat. Nos. 1001, 1002, 1003. Approved, for outside work for wires of signaling system, July 20, 1910. Manufactured by

Universal Specialty Company, 120 South Seventh St., Terre Haute, Ind.

MISCELLANEOUS.

Consolidated Buzzer System for use on electric cars or in power houses and car shops operating on 600 volt circuits, consisting of a fuse, resistance coil, interrupter and buzzers in series with a multiple series of push buttons. Approved, only when installed in compliance with requirements for car wiring or constant potential systems, and with push buttons in which the contacts are mounted upon bases of insulating fire resisting material, July 20, 1910. Manufactured by

Consolidated Car-Heating Company, Fisher Bldg., Chicago, Ill.

RECEPTACLES, FOR ATTACHMENT PLUGS.

"Arrow E" 12 A. 250 V. Flush Receptacle. Cat. No. 1062 with attaching plug 1065. Approved July 6, 1910. Manufactured by

Arrow Electric Company, 630 Capitol Ave., Hartford, Conn.

Hubbell" Flush Receptacles. Cat. Nos. 5498 and 5547, with plugs 5419-5421, inclusive, and Cat. No. 5566, with plug 5567, 10 A., 250 V. Cat. No. 5552, 20 A., 250 V., with plug 5553. Approved August 8, 1910. Manufactured by

Harvey Hubbell, Inc., Bridgeport, Conn.

"Hubbell" Surface Receptacles. Cat. Nos. 5617-5620, inclusive, 10 A., 250 V., with plugs 5419-5421 inclusive. Cat. Nos. 5621-5623, inclusive, 20 A., 250 V., with plug 5553. Conduit box types, Cat. Nos. 5614 and 5624, 10 A., 250 V., with plugs 5419-5421, inclusive. Cleat, concealed and moulding types, Cat. Nos. 5558, 5557 and 5559, respectively, 20 A., 250 V., with plug 5553. Approved August 8, 1910. Manufactured by

Harvey Hubbell, Inc., Bridgeport, Conn.

RECEPTACLES, STANDARD.

"Bryant" 660 W., 250 V. Sign, Cat. Nos. 1700, 4003, 40488, 46749 and 59108. Also 4014 ("Ruby" 102717) when installed so that both the porcelain base and metal rings are held by means of solder so that they cannot turn in the sign face. Cleat, Cat. Nos. 921, 1011, 1123, 4013, 9402, 9403, 11221, 28795, 50715, 58300, 58301, 58949. Concealed, Cat. Nos. 4000-4002, inclusive, 50744, also 9447, fusible, 2 A., 125 V. Moulding, Cat. Nos. 42453, 58302 and 58950. Conduit Box, Cat. Nos. 4003, 9397, 9514, 40507, 40537,59107, 62355, 62356 and 62357. Approved August 13, 1910. Manufactured by

Bryant Electric Company, Bridgeport, Conn.

"H. T. P. Co.," 660 W., 250 V. Sign Receptacles, Cat. Nos. 1700, 40488, 46749 and "Russell" 59439. Cleat Receptacles, Cat. Nos. 9402, 9403, 11221, 50715, and Fielding 23209, 23210. Concealed Receptacles, Cat. No. 50744. Moulding Receptacles (two-wire), Cat. Nos. 47567, 47568, Fielding 50724, 50726, also (three-wire) Fielding 36519. Conduit Box Receptacles, Cat. Nos. 9397, 40507 and "Russell" 47566. Condulet Receptacles, Cat. Nos. 46555, 47696. Approved August 11, 1910. Manufactured by

H. T. Paiste Co., 32d and Arch Sts., Philadelphia, Pa.

"P. & S.," 3 A., 250 V. Cleat, Cat. Nos. 61870 (870), 61871 (871), 64369 (821), and 66612 (822). Moulding, Cat. Nos. 61670 (670), 61770 (770), and 100136. Sign or Conduit Box Type, Cat. Nos. 975, 61072 (1072), 61777 (777), 61973 (973), and 61977 (977). Removable ring types, Cat. Nos. 61577 (577),

61578 (578), 61877 (877), 61988 (988), 102703 and 102704. Also 61900 (900), for use only in borders of double faced metal panel signs, and 61960 ready wired for sign work with receptacles spaced 4 inches on centers. This receptacle is also furnished wired with No. 12 or No. 14 wire and with spacings 5-30 inches on centers. Condulet Receptacle, Cat. No. 88259. Conduit Box Type, Cat. Nos. 9514, 50717, 62357, 103704 and 104603. Approved August 11, 1910. Manufactured by

Pass & Seymour, Inc., Solvay, N. Y.

"Marshall," 3 A., 250 V. Cleat Type, Cat. No. 44954. Approved July 11, 1910. Manufactured by

Marshall Electric Company, Hartford, Conn.

"G. E.," key and keyless types. Wall Sockets, brass shell. Key, Cat. Nos. 9184, 27742, 28721 (slotted or closed base), 29404, 29406, 50753 (slotted or closed base), and 60018, also 88959 (for use on metal ceilings). Keyless, Cat. Nos. 9185, 27743, 28722, 29405, 29407, 50755, 60019 and 60020, also 88960 (for use on metal ceilings). Porcelain Shell, keyless, 3 A., 250 V. Cleat type, Cat. Nos. 11221, 28794, 28795, 50715, 59275 and 61039. Concealed type, Cat. Nos. 49355, 50717, 50744. Also 50752, fused, 2 A., 125 V. Moulding types, Cat. Nos. 34152, 58303 and 100266. Conduit Box, Cat. Nos. 9397, 9514, 40537, 49354, 60931 and 62357. Sign Receptacle, Cat. Nos. 46627 and 105000. Approved July 22, 1910. Manufactured by

General Electric Company, Schenectady, N. Y.

RECEPTACLES, WEATHERPROOF.

"Paiste," 660 W., 600 V. Porcelain base receptacles, Cat. Nos. 9407, 9408, 9411 and 44912. Approved, for use with incandescent lamps in series on 600 volts circuits, August 11, 1910. Manufactured by

H. T. Paiste Co., 32d and Arch Sts., Philadelphia, Pa.

"Paiste," 660 W., 250 V. Porcelain base cleat receptacle. Cat. No. 59275. Approved August 13, 1910. Manufactured by

H. T. Paiste Co., 32d and Arch Sts., Philadelphia, Pa.

RHEOSTATS.

"G. E.," all capacities, 125-500 volts. Motor starters CR-107 and CR-109 (Type SA). Motor starters with field control, CR-162 (Type SFA). Speed regulating continuous duty, CR-151-154, inclusive, (Type RA). Printing press control, CR-170 and 170-A, CR-171 and 171-A (Type PB). Field Rheostats, CR-174 (Type F). Field Rheostats, sprocket driven, CR-178 (Type F). Field Rheostats, electrically operated, CR-179 (Type F). Also CR-111, CR-163 and CR-155 to 158, inclusive (Types SO, RO and SFO, respectively), with overload release devices which are inoperative during process of starting motor. Approved only when other circuit breakers or fuses are installed in connection with them. See N. E. Code Rule 60-g. Approved August 8, 1910. Manufactured by

General Electric Company, Schenectady, N. Y.

ROSETTES, FUSELESS.

"H. T. P. Co.," 3 A., 250 V. Cleat, Cat. Nos. 433, 434, 480 also 463, with sub-base 464. Concealed, Cat. Nos. 441 and 481. Moulding, Cat. Nos. 435 to 438, inclusive, and 482. Approved August 11, 1910. Manufactured by

H. T. Paiste Co., 32d and Arch Sts., Philadelphia, Pa.

SIGN MACHINES.

Single pole, single break, capacity 3 to 15 A. per switch, 110 volts. Single pole, double break, capacity 10 to 50 A. per switch, 110 volts. Single pole, script writing, capacity 1 A. per switch, 110 volts. Double pole, double break, capacity 20 to 50 A. per switch, 220 volts. Triple pole, double break, capacity 20 to 50 A. per switch, 110-220 volts. Approved, only when provided with cabinets complying with the requirements of the National Electrical Code, and when wired and installed in a manner satisfactory to inspection department having jurisdiction, July 11, 1910. Manufactured by

Electric Carriage Call & Specialty Co., 173 Christopher St., New York, N. Y.

SOCKETS, MINIATURE.

Miniature and Candelabra Socket, 75 W., 125 V. Pendant, Cat. Nos. 322 and 323. Brass Shell, Keyless, Cat. Nos. 320, 321, Pull, Cat. No. 386. Candle Sockets, Cat. Nos. 327, 328, 346 and 347 for use only in connection with porcelain candle. Approved August 11, 1910. Manufactured by

Bryant Electric Co., Bridgeport, Conn.

SOCKETS, WEATHERPROOF.

"P. & S.," 3 A., 250 V. Composition shall, Cat. Nos. 43310 and 60666. Porcelain shell, Cat. Nos. 9366 (116), 9448 (0116½) and 9496 (116½). Also 61418 (418) for festoon work, and 61420, ready wired for decorative work with sockets spaced 4 inches on centers and with insulated suspension cleat and hook, Cat. No. 430. This socket is also furnished wired with No. 12 or No. 14 wire and with spacings 5-30 inches on centers. Approved August 13, 1910. Manufactured by

Pass & Seymour, Inc., Solvay, N. Y.

SWITCHES, COMBINATION CUTOUT.

"Perkins," 10 A., 125 V. Double pole snap switches combined with Edison plug cutouts. Cat. Nos. 2300, 2360 and 2400. The switches are approved and labeled under the conditions stated on card 1464 A. dated April 15, 1910, filed Switches Surface Snap. Approved July 20, 1910. Manufactured by

Perkins Electric Switch Mfg. Co., Bridgeport, Conn.

SWITCHES, KNIFE.

"Barkelew" motor starting switches, for use with A. C. motors of not over 5 h.p. Spring-controlled double-throw knife switches equipped with cutouts for N. E. Code cartridge enclosed fuses. Fuses are in circuit only when switch is in running position. Type L, 2 and 3-phase, 30 A., 250 and 500 V. Approved July 6, 1910. Manufactured by

Barkelew Electric Mfg. Co., Middletown, Ohio.

SWITCHES, PUSH BUTTON FLUSH.

Diamond H. Single pole, 5 A., 250 V., 10 A., 125 V., Cat. Nos. 10 and 050. Double pole, 10 A., 250 V., Cat. Nos. 20 and 060. 3-way, 5 A., 250 V., 10 A., 125 V., Cat. Nos. 30 and 070. 4-way, 5 A., 250 V., 10 A., 125 V., Cat. No. 40. Also above types with lock attachment. Approved August 8, 1910. Manufactured by

Hart Mfg. Co., 103 Allyn St., Hartford, Conn.

SWITCH BOXES.

"S. E. Co." For flexible steel conduit, Cat. Nos. 5950, 6965, 6966, 6971-6978, inclusive. For steel armored cable, Cat. Nos. 5951, 6960, 6961, 6991-6998, inclusive. For rigid conduit, Cat. Nos. 3001-3006, inclusive, lined of unlined. Approved July 25, 1910. Manufactured by

Sprague Electric Co., 527 West 34th St., New York, N. Y.

TRANSFORMERS.

Air cooled transformer for outdoor use. Type SL, primary voltage 110 to 220, secondary voltage 10 to 20, capacity 1000 watts. Approved, only when installed and wired in both primary and secondary circuits in accordance with Class C wiring National Electrical Code, August 11, 1910. Manufactured by

Duncan Electric Mfg. Co., LaFayette, Ind.

"Beacon" transformer for use on 104-120 volt A. C. circuits. Type X delivering current on secondary side at 6, 12 and 18 volts. Approved, only for ringing bells and for similar signaling work and when primary wiring is installed in accordance with Class C of the National Electrical Code, July 18, 1910. Manufactured by

Electric Economy Co., 64 Warren St., Roxbury, Mass.

TUBING, FLEXIBLE.

Approved July 11, 1910. Manufactured by

Conduit & Cable Mfg. Co., Boston, Mass.

NEWS NOTES

INCORPORATIONS.

VISALIA, CAL.—The Terra Bella Water Company has been incorporated by Marco Hellman, A. A. Hart, W. A. Francis, F. J. Thomas and I. M. Walker, all of Los Angeles, with a capital stock of $25,000.

SPOKANE, WASH.—To develop the water-power on Warner Creek, in Lake County, Ore., the Southern Oregon Water Power Company, capitalized at $300,000, has been organized and soon will start work, it is announced on a $140,000 power plant to be used in supplying light and power. The president of the company is F. H. Oliver of Spokane, and M. R. Jennings, editor of the Edmonds Journal, is vice-president.

FINANCIAL.

WENATCHEE, WASH.—The Wenatchee Electric Company and the Entiat Power Company have pooled their interests and purchased the Valley Power Company. The new company will be known as the Wenatchee Valley Gas & Electric Company, with a capitalization of $1,000,000. Arthur Gunn will be president of the company.

TACOMA, WASH.—At the meeting of the executive board the sinking fund commission was authorized to issue $200,000 bonds, the proceeds to be expended in payment for work upon the Green river gravity water system for the city of Tacoma. Of this sum $100,000 will be used for work about the intake, and the balance of the fund will be used to pay for the preliminary work at the reservoir.

SAN FRANCISCO, CAL.—The advance in the common and preferred stocks of the Pacific Gas and Electric Company is said to be founded on increased earnings and the rumor that there is to be a melon cutting next year for the holdings of the common stock. The original trust agreement provided that no dividends were to be paid on common before 1911. The big disaster of 1906 followed so close upon the heels of the organization of the Pacific Gas & Electric that small hope was then entertained of so speedy a recovery of earning power. Last year's statement showed a balance of $1,502,957. For the first six months of 1910 the balance amounts to $943,-117.31. A duplication of earnings for the second half year will afford a surplus of $3,500,000 available for distribution. Houses that have made a specialty of Pacific Gas & Electric securities are predicting 6 per cent dividends on common for next year. This would mean an annual disbursement of some $1,200,000; an outlay which the record of the past 18 months would indicate was not beyond the power of the corporation. The company carries a heavy bond issue, reaching a total of $58,933,542. Against this it lists assets of $113,757,-660. Operating in 24 counties in the central part of the State, the corporation has been able to take advantage of the great growth of the last few years. The summary of earnings for the first six months of the year follows:

Gross revenue	$7,230,538.17	
Deduce rev. in sus. (S. F. r. case)	192,470.60	$7,038,067.57
Maintenance	$ 583,678.18	
Op. exp. tax, reserves, etc.	3,307,261.60	$3,890,939.78
Net revenue		$3,147,127.79
Int. (incl. int. on unify. & ref. bds)		1,511,742.27
Balance		$1,635.385.52
Div. on pfd. stock	$300,000.00	
Sinking funds	368,658.21	
Amort. of bd. dis. and exp.	23,610.00	692,268.21
Balance		$ 943,117.31

TRANSMISSION.

GRANGER, WASH.—The town council has granted a 50-year franchise to the Pacific Power & Light Company.

FLORENCE, ORE.—George M. Miller and brothers have completed surveys for the construction of a water-power plant near here and are seeking a franchise for furnishing light and power to the city.

EVERSON, WASH.—The Washington Mining & Development Company, of Bellingham, let a contract to Albert Rivers of this city, for the erection of poles on the streets of this place and Nooksack.

GRANTS PASS, ORE.—M. J. Anderson of this place is working on a large power project on the South Fork of the Coquille river, about 30 miles southeast of Myrtle Point, where from 5000 to 10,000 h.p. can be developed.

OAKLAND, CAL.—The Sierra and San Francisco Power Company has applied for a franchise, under which it intends to operate a telephone line through the county. The line is to be used by the company alone and will in no way be a public service corporation. The Sierra and San Francisco Power Company has been operating in this county for two years. It has been supplying a number of local firms with power, and now intends to widen the field. Under the franchise the company proposes to run wires for the transmission of electric power, and, on the same poles, its telephone wires.

VERDI, NEV.—The hydroelectric power plant to be built on the Truckee river, a short distance east of Verdi, at the end of a big canal which will tap the Truckee near Boca, a few miles above Verdi, and will be large enough to carry all the water in the Truckee, will develop 3000 h.p. It is to be built by the Sierra-Pacific Electric Company, which was organized by W. P. Hammon and associates, and which is the holding company for the Truckee River General Electric Company, Reno Power, Light & Water Company, Washoe Power & Development Company, and Union Gas Company. The Sierra Pacific Company, has at present power plants at Farad, Washoe, Reno and Fleish, which develop 7800 h.p., but the new plant will develop nearly half as much as all these plants combined. J. B. Lukes, who is the engineer in charge of the project, states that the company has plenty of use for this additional power. Engineering parties are now in the field, and the right of way for the canal is being secured. It is stated that a sixth plant may be built just east of Reno after the completion of the proposed Verdi plant.

TRANSPORTATION.

BROWNSVILLE, ORE.—The Albany Interurban Railway Company has asked for a franchise here.

BELGRADE, MONT.—The Galaltin Valley Electric Railway Company, will build a branch from Buckley's ranch, south of Central Park, to this place.

STOCKTON, CAL.—The electric line known as the Jenny Lind line which has been completed to Linden, will be extended on to Jenny Lind at once.

EUGENE, ORE.—The franchise for the Oregon Electric Company has been granted under which the company is to have the line completed and in operation between this place and Albany within 18 months.

LOS ANGELES, CAL.—The City Clerk will receive sealed bids to 11 a. m. September 20th, for a franchise granting right to construct and for a period of 21 years to operate and maintain a double track electric railroad on Brooklyn and Evergreen avenues. H. J. Lelande, City Clerk.

CITY OF MEXICO, MEX.—The Department of Public Works has under consideration the proposed new line of the Mexico Tramways Company, which will pass through the colonies of Indianola and El Buen Tono to the general hospital.

SOUTH BEND, WASH.—J. B. Crary, former manager of the Grays Harbor Electric Light & Power Company of Aberdeen, announces that he is interested in the probable construction of an electric railway to cost $500,000 between South Bend and Raymond.

OAKLAND, CAL.—The City Council has granted to the Southern Pacific Company a 50-year franchise for the extension of its Melrose and annexed territory branch of the ferry service lines to Stanley road. The extension, as well as all of the corporation's local lines, will be electrified. The franchise grants the S. P. the right to carry freight over the road during the night.

SANTA ROSA, CAL.—Petaluma and Santa Rosa electric railway officials have bonded the summer resort known as Mirabel Park, on the Russian river, and taken options on many other pieces of property in that section. Surveys are being made from Forestville, the terminus of the road at the present time, to Mirabel Park, one mile and a half distant and construction work will be begun this fall. It is intended to build the electric line down the river westward and touch all the principal summer resorts as far as Monte Rio.

SAN FRANCISCO, CAL.—The Northern Electric Company will within a few days, issue a new time table for its trains between Sacramento, Marysville, Oroville and Chico. There will be no change in the number of trains run, but merely a change in the running time. The time between Sacramento and Marysville will be lessened about ten minutes and about that much added to the running time from Marysville to Chico. Failing to reach a settlement of the strike of linemen and operators of the Northern Electric Company with the officials of the railway in San Francisco, Hugh Murrin, president of the district council of the Electrical Workers' Union, is to take charge of the situation. So far the Northern Electric Company has been able to operate its trains notwithstanding the strike.

ILLUMINATION.

REDMOND, ORE.—The City Council has granted a franchise to the Creek County Water, Power & Light Company, a local organization for an electric lighting and power system here.

NEW ARLINGTON, CAL.—Wm. V. Lockwood, representing a large electric contracting concern is figuring with the Arlington Hotel Company, on installing a light and power plant for New Arlington.

SAN BERNARDINO CAL.—The City Council has formally declared in favor of a municipal lighting and power plant and a committee has been appointed who will report in a month the cost of installing a lighting plant.

OGDEN, UTAH.—When the present improvements planned by the Pintsch Compressor Company are completed, Ogden will have the fourth largest gas plant in the United States. The present capacity of the plant is to be increased from 50,000 to 200,000 cubic feet per day, and the work of placing the necessary equipment for the enlarged capacity is to start at once.

MYRTLE CREEK, ORE.—It has been decided to construct an electric light, heat and power system and to transmit and sell electricity at Myrtle Creek, Canyonville and Riddle if a sufficient load can be obtained. The power will be generated by steam. This plant will be a temporary one and will be replaced by a larger one in a few years. J. L. Blaisdell of Portland, Ore., is one of the men interested in the project.

WATERWORKS.

NAMPA, IDAHO.—Messrs. Dutcher and Ednie have secured the contract to install the new water system in the town of Meridian.

WESTON, ORE.—The Council has made a contract with J. Franklin, of Walla Walla, for improvements in the local waterworks system to cost $3370.

WESTON, ORE.—The city of Weston has contracted with Jesse L. Frankum of Walla Walla for improvements in the waterworks system to cost $3370.

JOSEPH, ORE.—J. Mitchell of Joseph will install a new water system for $16,800. It is the intention to connect the large feed main with Wallowa Lake, one mile south of the town.

SAN FRANCISCO, CAL.—The Board of Health has been allowed $30,000 for the purpose of equipping the infirmary at the Relief Home and $20,000 has been awarded to the Board of Public Works to provide additional plans and specifications for the auxiliary system for fire protection.

SPOKANE, WASH.—Spokane will lay plans for a gravity water system. The matter was laid before the leading citizens at a meeting of the Spokane Chamber of Commerce by Mayor N. S. Pratt, and was turned over to the Chamber's special water committee for full investigation. The cost of the plans will approximate $1,000,000.

SEATTLE, WASH.—The Vashon Country Club is being organized and has purchased 8 acres of land located on the north end of Vashon island on which it proposes to erect a club house and will also install a water system. Those interested are J. Roberts, J. Braid, B. Wadell, Geo. Francis Rowe, J. Leslie, B. Petty, R. Cameron and C. Brockhagen.

LODI, CAL.—The bids for installing the municipal water plant were opened at the meeting of the trustees and they were as follows: Williams & Belser, San Francisco, $6793; Appleton & Frederickson Bros., $6901.75; Ernest H. Fink, $7300. After the bids had been referred to the city engineer, H. H. Henderson, and City Attorney E. I. Jones, it was decided to award the contract to Williams & Belser.

OAKLAND, CAL.—The Board of Public Works has adopted a resolution recommending to the City Council that a sum be appropriated by the city for the extension of the recently installed salt water fire fighting auxiliary system along Fourteenth street from Washington to Market street. With the contemplated addition, the system will extend from Fourteenth street to First, and from Market to Oak street, and will place every part of the business district within its confines.

LOS ANGELES, CAL.—Work on the Los Angeles aqueduct is again progressing at the rate of five miles a month and is costing about $10 per lineal foot. The only problem left in completing the ditch on time is that of steam shovel work. The general work is moving faster and costing less than was anticipated. According to the original aqueduct estimates the entire work was to cost an average of $22 a lineal foot. Nearly all of the accessory and preliminary work is now out of the way, and the actual construction figures, averaging the tunnels, conduit and canal, have been reduced to $10 a foot. This includes over $1,000,000 worth of conduit covering which was not included in the original estimates. Full forces are now operating at both the north and south portals of the Elizabeth tunnel. On the 1st inst., there had been completed 22.284 feet of this tunnel and there remains but 4576 feet to put through. The Haiwee dam work is being pushed rapidly with a strong force. On the four long tunnels of the Grapevine division full crews are at work. Chief Engineer Mulholland says: "At the rate of five miles a month, as we are going now we should easily complete the work on time."

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No. 8.—CONCRETE STEEL. For given cross-section of steel determines the spacing for various sizes of round and steel bars.

Nos. 11, 12.—POLE LINE CONSTRUCTION. COPPER. For given length of span, given deflection and assumed temperature determines the strain at the center of the span.

No. 13.—POLE LINE CONSTRUCTION. ALUMINUM. Same as Nos. 11 and 12.

No. 14.—ELECTRIC CIRCUITS. For given horsepower or kilowatts and given voltage determines the actual amperes transmitted at various power factors for both single-phase and three-phase circuits.

No. 15.—POWER TRANSMISSION LINES. COPPER. 60-CYCLE. For given wire spacing and size determines impedance for both single-phase and three-phase circuits; also for given number of amperes determines the volts drop per mile.

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No. 19.—ECONOMIC SIZE OF PIPE. Determines the best pipe diameter for carrying a given volume of water under a known head for various power values (dollars per horsepower year) as compared with the price of steel.

No. 20.—FLOW OF WATER IN SMALL PIPES. Determines the friction head per 1000 feet of pipe of capacity and diameter.

No. 21.—CANALS IN EARTH. For given hydraulic radius or area of cross-section and for given slope determines the carrying capacity in second-feet or miner's inches for various values of n.

No. 22.—WATER POWER. GENERATING AND PUMPING. For given quantity in second-feet or miner's inches and given head determines either the power generated or the power necessary to pump at various efficiencies.

No. 23.—STEEL PIPE LINES. For given diameter of pipe and given head or pressure per square inch determines the weight per foot and the thickness of steel for both double riveted lap joint and triple riveted butt joint pipe.

Nos. 24, 25, 26, 27, 28 and 29.—FLOW OF WATER IN PIPES. For given quantity of flow and given diameter of pipe determines the velocity in feet per second and the friction head per 1000 feet for all values of n.

No. 30.—WOOD-STAVE PIPE LINES. For given diameter of pipe and given head determines the distance between bands and the weight of metal per foot.

No. 31.—FLOW OF WATER OVER SHARP-EDGED WEIRS. (Bazin's Formula.) For observed head in feet and given height of weir determines the second-feet discharged per foot of weir length.

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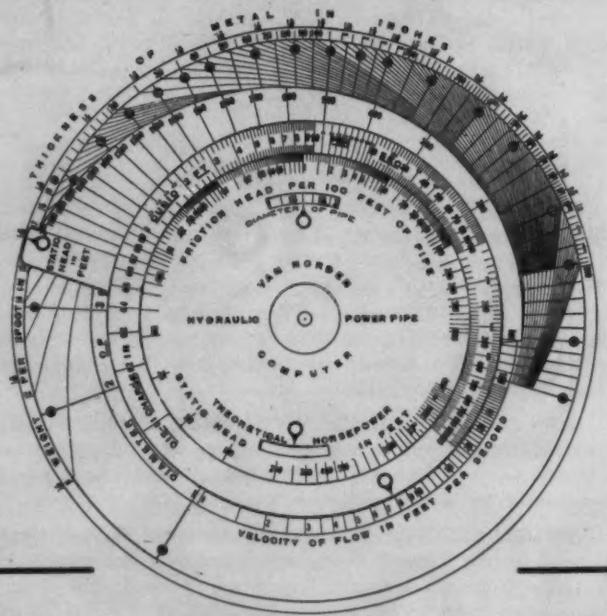

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